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Biology of Selected Fish Species in the Moose River Basin.

Seyler, John

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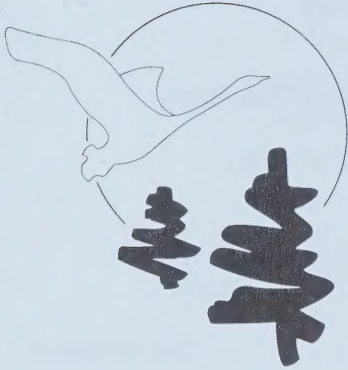
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EXECUTIVE SUMMARY

This report summarizes all that is known about the distribution and ecology of selected river dwelling fish species in the Moose River Basin. Detailed information on lake sturgeon, walleye, northern pike, smallmouth bass, lake whitefish, goldeye, mooneye, common white sucker and longnose sucker, describing life histories, habitat use, diet and contaminant levels is provided. The impacts of instream development on these fish species are discussed.

Rivers of the Moose River Basin are highly fragmented. There is great potential for additional instream development. Knowledge of fish and fish habitat relationships is the major information gap impeding the management of fish communities in these rivers. Direction for acquiring necessary information and developing tools to manage fish is provided for river managers.

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1.0 INTRODUCTION

The Bibliography of Literature on Large River Ecosystems in the Moose River Basin (Fiset *et al.* 1994) references 175 scientific and technical reports that contain fisheries information. This review is an extension of the bibliography as it summarizes what we know about selected fish species and communities in the Basin.

This review focuses on fish species most commonly encountered and studied in large rivers within the Basin. Information on species distribution, abundance, behavior and population characteristics is presented. The impacts of anthropogenic stresses such as hydroelectric generation, the pulp and paper industry, and sport and commercial fisheries are discussed. As our knowledge of fish communities in northeastern Ontario rivers improves, many additional questions come to light. Information gaps are identified in this review in order to provide direction for future fisheries investigations.

1.1 INFORMATION SOURCES

Primary literature and technical reports listed in Fiset *et al.* (1994) are the principal sources of information used in this report. Significant bodies of work e.g. Scott and Crossman (1973) and fish habitat suitability index (HSI) models, are referenced where they help to fill in gaps in the ecology and life history of river dwelling species found in the Basin.

Analysis of raw and unpublished data was not undertaken as part of this review. Data sets containing catch records and habitat parameters are used to describe fish assemblages and habitat utilization relationships. Extensive fisheries information exists as 'gray literature' which includes field records and unpublished technical manuscripts. These sources are cited where they contribute to our understanding of river fish communities.

The majority of fish contaminant data reported in this review were acquired from the Ontario Ministry of Environment and Energy (MOEE) and were collected as part of the Provincial Sport Fish Contaminant Monitoring Program. These results are supplemented with data collected on behalf of developers, by consultants.

1.2 OVERVIEW OF RIVERS IN THE MOOSE RIVER BASIN AS FISH HABITAT

The Moose River Basin drains approximately 109,000 square km, traversing three physiographic regions: the Canadian Shield, Northern Clay Belt and Hudson Bay lowlands (Brousseau and Goodchild 1989). Through each of these regions, rivers acquire distinct characteristics related to topography, soils and climate. A casual observer travelling northward along a given river, from the Basin's origin on the Shield to the mouth of the Moose River on James Bay, might well conclude that he or she had actually passed over several different rivers due to the physical changes that occur along these river continuums. The mean annual length of growing season varies from approximately 170 days at the height of land to 154 days in the lowlands (Brousseau and Goodchild 1989, Royal Commission on Northern Environment 1985). Similarly mean annual growing degree days varies between 1200, on the shield, to 1100 at James Bay. Along an east-west axis the landscape changes from typically rolling topography of the Abitibi uplands to flat, wet, black spruce forests. The consequence of these changes in landscape is that no two rivers appear to be the same at a given latitude.

Throughout the Basin there are a number of natural and man-made barriers impeding upstream movement by many fish species (**Figure 1**). In some cases where barriers have been constructed, natural impediments to movement probably existed before development. The occurrence of barriers may have genetic implications, however, this aspect of fish distribution in the Basin is poorly understood. The downstream movement of species and mixing of stocks likely continues despite instream development. Dynesius and Nilsson (1994) concluded that the Moose River Basin was among the most highly fragmented river systems in the northern third of the world.

Rivers on the Shield, such as the upper Missinaibi River, have irregular gradients and are typically, less than 100 m wide. River channels are tightly contained. Bedrock outcrops are common, manifested as extensive riffle and rapids areas. Bottom substrates are predominately coarse gravel and rubble. Inflowing tributaries are generally small. Many tributaries are coldwater and contain natural brook trout (*Salvelinus fontinalis*) populations. The water in these sections of river is often tea coloured. Although there is currently no hydroelectric development on the upper portions of the Shield, headwater and mainstream storage reservoirs are located on the Groundhog, Ivanhoe and Mattagami Rivers. These reservoirs are drawn down two to four meters during late autumn and winter months in order to maintain downstream flows, and periodically in the spring for flood control.

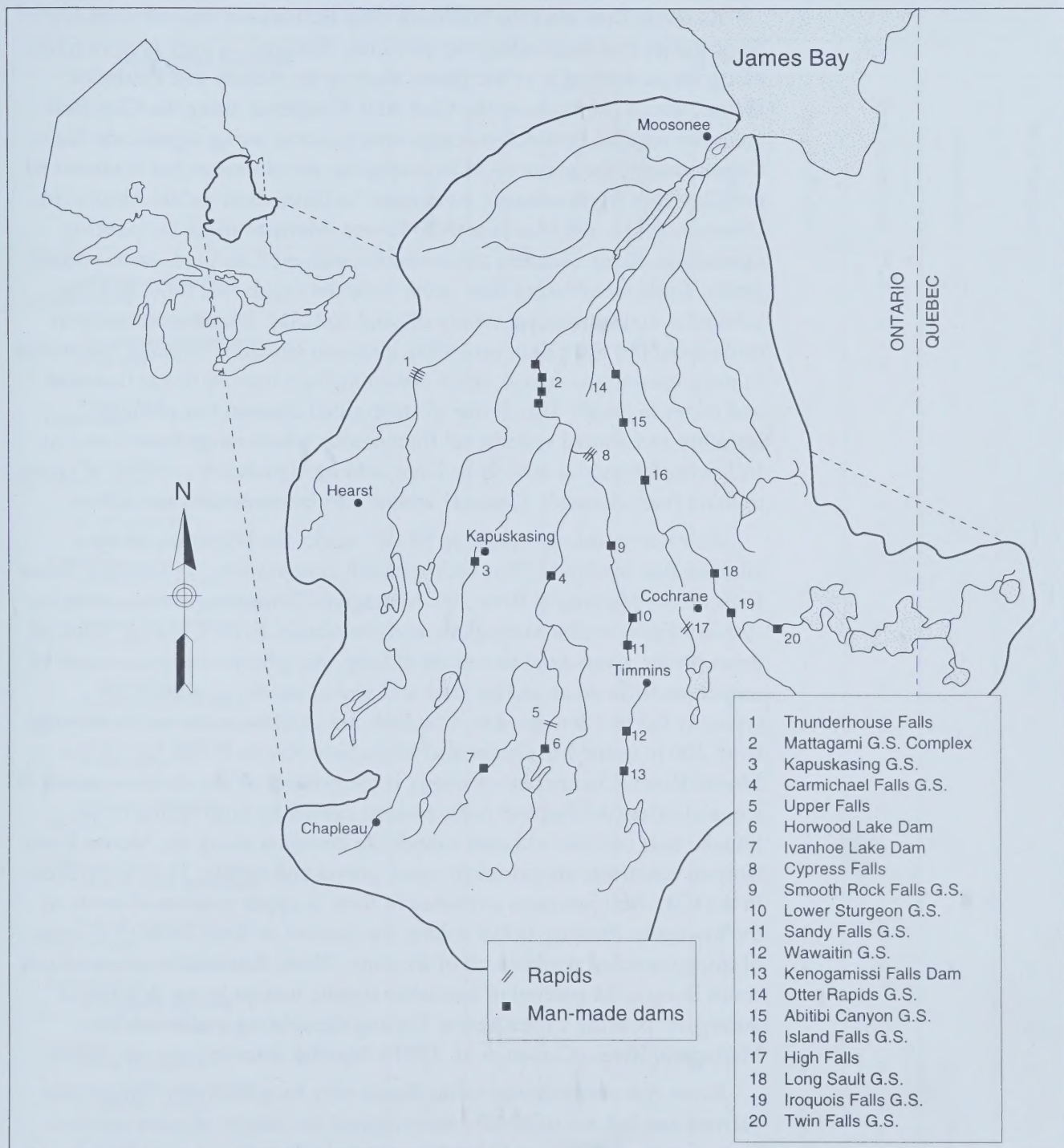


Figure 1: Natural and man-made barriers impeding upstream fish migration, Moose River Basin.
(Inset: Moose River Basin, Provincial perspective)

As rivers flow over the Northern Clay Belt waters take on a muddy color due to fine suspended clay particles. Turbidity is very high in rivers along the eastern edge of the Basin, such as the Abitibi and Frederick House, which originate on the Clay Belt. Gradients along the Clay Belt are more regular. Bedrock outcrops tend to occur along significant faults. Consequently, the majority of hydroelectric development has occurred in the Clay Belt. Hydroelectric generation facilities exist on the Abitibi (6), Groundhog (1), and Mattagami (8) Rivers. Many of these are peaking operations. River channels are contained with well defined, narrow flood plains. Long meandering runs occur between rapids and falls. Bottom substrates consist predominately of sand and clay. Islands are common throughout the Clay Belt, providing instream structure. Aquatic vegetation in main channels is sparse, often consisting of a narrow fringe less than one meter in width. This is due to steep sided channel morphology, turbidity and annual water level fluctuations which range from 2 to 3 m. Inflowing tributaries tend to be large, adding significant volumes of water to main river channels. Channel widths vary between 100 and 200 m.

An escarpment near latitude 50° 00" marks the beginning of the Hudson Bay lowlands. This bedrock fault is manifested as Thunder House Falls on the Missinaibi River, the Mattagami Generating station complex (Smoky Falls) on the Mattagami, and the Abitibi River Canyon. North of these points, rivers tend to consist of long, straight reaches punctuated by numerous riffle areas and by sand and gravel shoals. Gradients are typically 0.5 to 1.0 m per km. Channels are shallow, with widths varying from 200 m in the Missinaibi and Mattagami Rivers to one km on the Moose River. Channel morphology is the product of the abrasive action of ice, and extensive bed and bank erosion caused by high spring flows. Shoals, bars and mid-channel islands are common along the Moose River. Bottom substrates are primarily sand, gravel and rubble. Flow regulation in the Clay Belt produces extremes in flow in upper reaches of rivers in the lowlands. Peaking flows reduce the channel in these areas to a series of interconnected pools much of the time. Water flow and level variations result in up to 34 percent of available aquatic habitat being dewatered during the peaking cycles below Kipling Generating station on the Mattagami River (Carson *et al.* 1991). Aquatic macrophytes are sparse.

River fish communities in the Basin vary longitudinally. Impassable barriers and habitat suitability have limited the ranges of some species. Brousseau and Goodchild (1989) provide the best synopsis of fish species presence and absence data for both lakes and rivers in the Basin. Table 1, summarizes information on river communities based upon up-to-date inventory data.

Table 1: River fish species in the Moose River Basin.

Family and Species	Locations								
	Moose River	Missinaibi River	Abitibi River	Frederick House River	Mattagami River	Groundhog River	Kapuskasing River	Ivanhoe River	Chapleau River
Acipenseridae									
<i>Acipenser fulvescens</i>	x	x(1)	x	x	x(1)	x	x(1)	x(1)	
Salmonidae									
<i>Salvelinus fontinalis</i>	+	+	+	+	+	+	+		
<i>Coregonus clupeaformis</i>	x	x	x	x	x		x	x	x
<i>C. artedii</i>	x			x	x		x	x	x
Esocidae									
<i>Esox lucius</i>	x	x	x	x	x	x	x	x	x
Hiodontidae									
<i>Hiodon alosoides</i>	x		x	x	x(1)				
<i>H. tergisus</i>	x	x(1)	x	x					
Catostomidae									
<i>Catostomus catostomus</i>	x	x	x	x	x	x	x		
<i>C. commersoni</i>	x	x	x	x	x	x	x	x	x
<i>Moxostoma</i> sp.		x(1)	x	x	x				
Cyprinidae									
<i>Couesius plumbeus</i>			x	x	x	x			
<i>Notemigonus crysoleucas</i>			x	x	x		x		
<i>Notropis atherinoides</i>			x	x	x	x	x		
<i>N. cornutus</i>		x			x	x	x	x	x
<i>N. heterolepis</i>	x	x		x	x	x	x	x	
<i>N. hudsonius</i>		x	x	x	x	x	x	x	x
<i>Pimephales promelas</i>					x	x			
<i>Rhinichthys cataractae</i>	x	x	x	x	x	x	x	x	x
<i>Semotilus corporalis</i>	x	x	x(1)		x(1)				
<i>S. margarita</i>			x		x	x			
Ictaluridae									
<i>Ictalurus nebulosus</i>			x(2)	x			x		
Gadidae									
<i>Lota lota</i>	x	x	x	x	x	x	x	x	x
Gasterosteidae									
<i>Gasterosteus aculeatus</i>	x								
<i>Culaea inconstans</i>	x				x	x			
<i>Pungitius pungitius</i>	x	+	+		x	+	+		
Percopsidae									
<i>Percopsis omiscomaycus</i>	x	x	x	x	x	x	x	x	x
Centrarchidae									
<i>Ambloplites rupestris</i>			x	x					
<i>Micropterus dolomieu</i>		x(2)			x(2)				x(2)
Percidae									
<i>Perca flavescens</i>	x	x	x	x	x	x	x	x	x
<i>Stizostedion canadense</i>			x	x					
<i>S. vitreum vitreum</i>	x	x	x	x	x	x	x	x	x
<i>Etheostoma exile</i>						x	x	x	x
<i>E. nigrum</i>	x	x	x	x	x	x	x	x	x
<i>Percina caprodes</i>	x	x	x	x	x	x	x	x	x
Cottidae									
<i>Cottus bairdi</i>	x	x	x	x	x	x	x	x	x
<i>C. cognatus</i>	x								
Total (Resident spp. only)	22	20	25	24	28	23	18	17	15

x - river residents

x(1) - resident, lower reaches only

x(2) - resident, upper reaches only

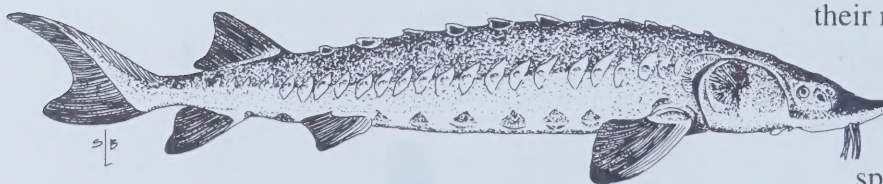
+ - present in tributaries, occasional residents

Compared to large rivers located in more temperate areas of North America, the rivers in the Moose River Basin contain relatively simple fish communities. Species diversity is highest within the Hudson Bay lowlands and lowest in the upper, shield portions of rivers. Rivers flowing through more than one physiographic region generally contain the most diverse fish communities.

2.0 LAKE STURGEON (*ACIPENSER FULVESCENS*)

More effort has been directed toward understanding the biology of lake sturgeon (*Acipenser fulvescens*) in the Basin than any other fish species. Sturgeon are distributed throughout the lowlands and portions of the Clay Belt but are absent from the uppermost, shield portions of the Basin (**Figure 2**). Sturgeon presence is essentially limited to rivers, however, there have been undocumented reports of lacustrine populations

near the southernmost edge of their range, in the Clay Belt (J. Cavanagh pers. comm.).



Lake sturgeon spawning activity in

the Moose River Basin has been poorly documented.

Spawning activity has been reported below rapids on the Mattagami, the Ivanhoe and the Groundhog Rivers (Rich 1987, J. Cavanagh pers. comm.; Seyler 1995 unpub. data). Radio telemetry data has shown that large numbers of adults begin moving towards spawning areas several weeks prior to spawning, when water temperatures reach 6 to 9 C (NEA 1992, McKinley *et al.* 1990). Sturgeon overwintering in the Little Long headpond migrate more than 42 km in order to access a suspected spawning site at Cypress Falls on the Mattagami River (Sheehan and McKinley 1992).

Kempinger (1988) reported that water temperature strongly influences spawning activity. Researchers have documented peak spawning activity at water temperatures of 11 to 15 C (Kempinger 1988, LaHaye *et al.* 1992). Kempinger (1988) noted that the majority of lake sturgeon spawning on the Wolf River, Wisconsin were located close to shore in less than 2.5 m of water. LaHaye *et al.* (1992) reported that lake sturgeon eggs were deposited in less than 1 m of water over coarse gravel and cobble substrates. Current velocities at these locations ranged from 0.61 to 0.84 m/s. The authors noted that lake sturgeon congregated behind large boulders which acted as breaks from stronger currents. Lake sturgeon eggs are adhesive, attaching to bottom substrate to incubate (Kempinger 1988).

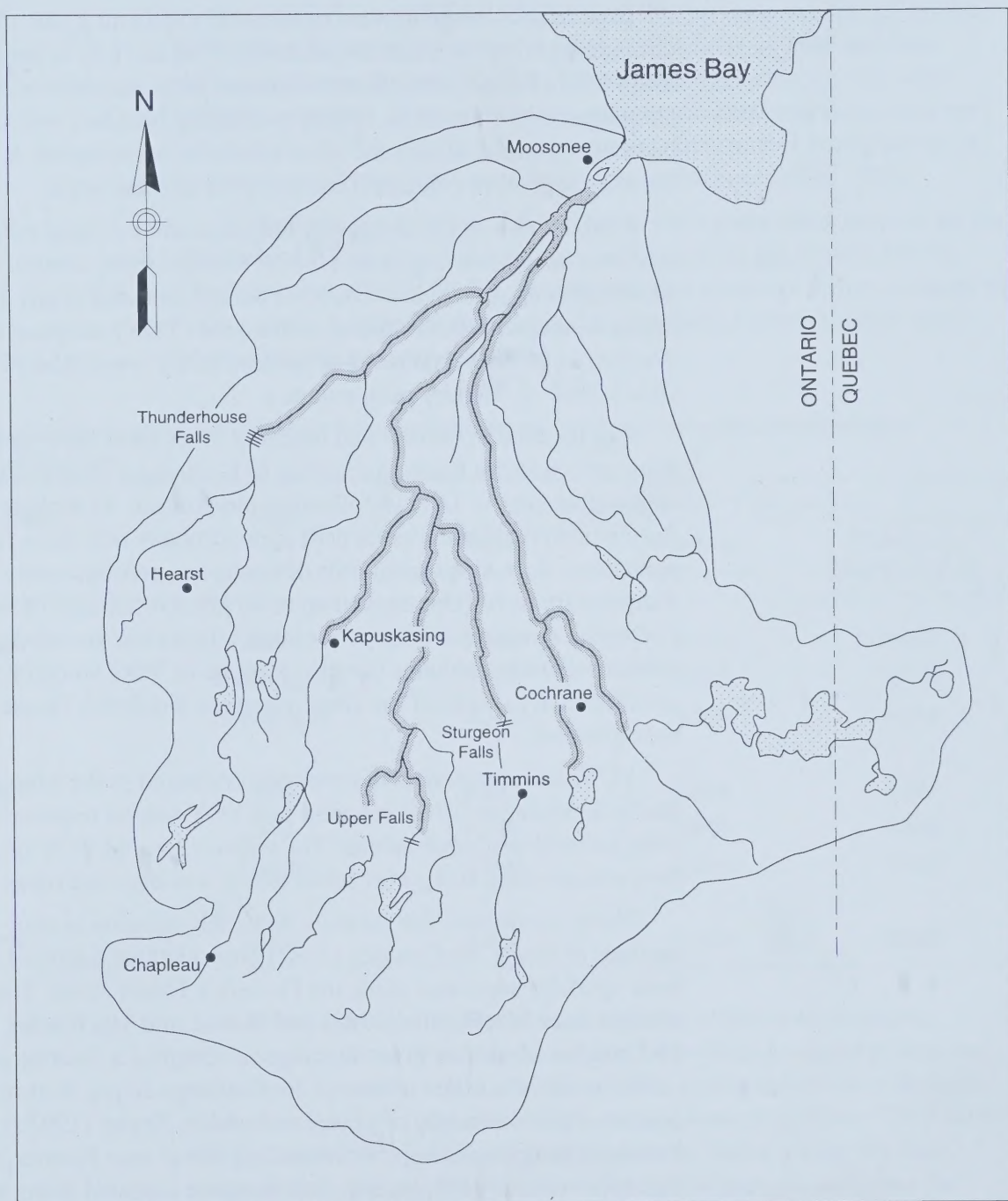


Figure 2: Documented distribution of lake sturgeon (*Acipenser fulvescens*) within the Moose River Basin.

Ripe female sturgeon were captured at a spawning site on the Groundhog River at water temperatures of 10 to 11 C, in the third week of May, 1995 (Seyler 1995). In this instance, large numbers of sturgeon congregated in quiet areas, behind protruding boulders over rubble and bedrock substrate, at the base of an extensive set of rapids. It was unclear whether eggs were deposited and fertilized in these areas.

Predation on sturgeon eggs by longnose and common white suckers has been documented by Rich (1987). Rossiter (pers. comm.) noted that no sturgeon eggs were discovered in the gut contents of any fish species on the Mattagami River. Young-of-the-year (YOY) sturgeon have been discovered in the gut contents of walleye in the lower Abitibi River (EAG 1980, C. Hendry pers. comm.).

Egg incubation periods and hatching times have never been documented in the Basin. According to Kempinger (1988) lake sturgeon eggs hatch eight to 14 days following fertilization. Kempinger documented maximum larval drift approximately nine days following the peak hatch. Larval sturgeon drift downstream, predominately at night. Sturgeon fry have been tracked up to 40 km downstream of hatching sites in Quebec rivers (R. Fortin pers. comm.), however, knowledge of YOY habitat utilization remains sketchy. Reports of YOY sturgeon presence in small tributary creeks of the Groundhog and Frederick House Rivers are unconfirmed.

YOY lake sturgeon have never been captured in the Moose River Basin. Kempinger (1996) reported that YOY habitat requirements differ from juvenile and adult habitat. The author captured YOY lake sturgeon over smooth sand and gravel substrates in less than one meter of water.

There is evidence that juvenile and adult sturgeon occupy distinct sections of rivers. McCrudden (1982) observed that adults and juveniles were spatially separated along the Frederick House River. This is also alluded to by MacRitchie (1983) and Nowak and MacRitchie (1984). McCrudden noted that juvenile sturgeon occupied a discrete area at the convergence of a major tributary, the Bushkego River. Bottom substrates consisted predominately of gravel and rubble. Seyler (1997a) conducted extensive sampling along the Groundhog River near Faquier, and found that approximately 90 percent of all sturgeon captured there, were juveniles. Reaches located further upstream are inhabited almost exclusively, by adults (Seyler 1997b). Phoenix and Rich (1988) and NEA (1989) note that sections of the Groundhog River, near Carmichael Falls, also contain predominately juvenile sturgeon. Threader and Brousseau (1986) concluded that 90 percent of all sturgeon sampled near the junction of the Moose and Abitibi Rivers were juveniles.

Seyler (1997) and NEA (1992) report that juvenile abundance on the Groundhog River, is highest in pools 4 to 9 m deep, in May and June during the spring freshet. Habitat preference curves indicate that where velocity exceeded 70 cm per second, sturgeon habitat utilization was very low (Seyler 1997a). Radio telemetry results showed that young sturgeon generally move very little over the course of the year (NEA 1992).

Table 2 summarizes catch data from several assessment projects on the Groundhog River using habitat types established as per Seyler (1997a). Catch per unit effort (CPUE) data indicate that juveniles utilize a variety of habitat types throughout the summer and autumn, however, pools likely play an important role year round.

Table 2: Juvenile sturgeon catch per unit effort by macrohabitat type, from selected assessment studies, Groundhog River.

Reference	Time	Catch per Unit Effort (no. per hr.)		
		Pools (depth > 6 m)	Shallows (depth < 3 m)	Flats/Runs (depth 3 - 6 m)
Seyler (1997a)	June	0.205	0.064	0.080
	July/August	0.120	0.090	0.126
	September	0.035	0.061	0.096
NEA (1992)	May	0.982	0.294	0.277
	June	0.748	0.256	0.304
	August	0.758	0.304	0.438
NEA (1989)	June	1.825	0.129	0.082

Adult sturgeon habitat utilization is poorly understood, however, several radiotelemetry studies have been undertaken to examine seasonal movement. Phoenix (1991) and NEA (1992) implanted adults with radio transmitters, below Carmichael Falls on the Groundhog River. They were initially captured in a series of pools below the Falls in May. By June, many of these sturgeon moved 20 to 30 km downstream and spent the summer months in channel flats and runs. Several individuals moved approximately 3 km up a small tributary, the Wakusimi River, prior to the spring freshet and moved back into the Groundhog River in July. Very little movement occurred between July and September. The majority of radiotagged sturgeon returned to the initial capture location and remained there over the winter. Adults tagged above Carmichael Falls (NEA 1992) also utilized deep pools during winter months and at the height of the spring freshet. Following the freshet sturgeon moved extensively both up and downstream, returning in the autumn.

McKinley *et al.* (1990) recorded the movements of 19 adults in the Little Long headpond on the Mattagami River. Adults migrated upstream, 40 km to Cypress Falls, an impassible barrier and suspected spawning area, at the onset of spring freshet. After spending several weeks in the vicinity of Cypress Falls, there was a mass migration downstream into the headpond where sturgeon spent the summer months. In the autumn, at low flows, many sturgeon moved back upstream into riverine portions of the system but overwintered in the deeper water of the Little Long headpond. Adults from this population move very little over the course of the winter (S. McKinley pers. comm.).

The majority of nineteen adult sturgeon tagged below Kipling Generating Station in the lowlands, occupied pools in the vicinity of their capture area, year round. Three adults moved more than 22 km downstream and did not return. Several sturgeon which were radiotagged in pools in the Adam Creek diversion channel were displaced by high flows during the freshet but returned to these pools when the freshet abated.

The results of these projects suggest that adult lake sturgeon move extensively prior to maximum flow periods in order to access spawning sites. However, deep pools may play an important role as refugia following spawning and during winter months. Pools may be of critical importance downstream of peaking operations such as Kipling Generating Station year round. During low flow periods in the late summer and autumn, adults utilize a variety of habitats, likely to forage for food.

The impacts of habitat fragmentation caused by dam construction is unclear. Movements by individual sturgeon, greater than 40 km have not been reported in the Basin. Sheehan and McKinley (1992) and Gibson *et al.* (1984) reported that sturgeon utilize the entire length of river available to them between dams and natural barriers on the Mattagami and Abitibi Rivers, respectively. Many dammed sites likely represented natural migrational barriers prior to construction. Population collapses have been documented in headponds along the Mattagami River (Nowak and Hortiguera 1986, Payne 1987, KGS *et al.* 1991) where sturgeon have been confined to discrete areas between impoundments. Gibson *et al.* (1984) and CIMA (1991) hypothesize that the sturgeon population inhabiting the upper Abitibi is in danger of collapse due to recruitment failure associated with habitat fragmentation and flow manipulation.

NEA (1992,1993) and BAR (1995) document anoxic conditions in a run-of-the-river hydroelectric generating facility headpond on the Groundhog River. Following construction, juvenile sturgeon congregated in the Carmichael Falls Generating Station headpond year round. When the headpond became anoxic in the summer of 1992, sturgeon abandoned this area, dispersing upstream and downstream, through the dam.

Subsequent assessments concluded that very few sturgeon have returned to the headpond four years after this incident. Sturgeon abundance immediately downstream of the facility has increased. Many of these fish had previously been captured and tagged in the headpond.

In 1960, the Adam Creek diversion was constructed on the Mattagami River in order to spill excess water around the Mattagami Generating Station complex. Spillway operation in the spring periodically coincides with the return of adults to the Little Long Headpond following the spawning period. Sturgeon passing near open spillway gates are flushed downstream and become entrained in pools (Seyler *et al.* 1996). McKinley and Power (1995) suggest that continual losses of adults predisposes sturgeon populations to collapse, leading to low recruitment. The authors hypothesize that lake sturgeon longevity and repeat spawning are evolutionary adaptations which compensate for high natural juvenile mortality. Ontario Hydro and Mattagami River managers are currently examining options to minimize entrainment at this site.

Rossiter *et al.* (1995) undertook an extensive examination of lake sturgeon feeding ecology on the Groundhog and Mattagami Rivers. The authors found that sturgeon are generalist feeders, foraging almost exclusively on macroinvertebrates. Preferred food items include *Hexagenia*, Diptera and Odonata larvae. Based upon estimated invertebrate density, the authors conclude that individual sturgeon are required to deplete an area of 13 m² in order to obtain the mean number of preferred food species recorded in gut content analysis. There appears to be no dietary partitioning over various size ranges of sturgeon resulting in intensive competition for available food sources. The diet of sturgeon at this study site overlapped most with the diet of burbot (A. Rossiter pers. comm.).

McKinley *et al.* (1993) reported that the gut contents of sturgeon collected above the Mattagami Generating station complex contained primarily *Hexagenia* spp. however, sturgeon captured downstream fed primarily on crayfish and cyprinids. The authors examined non-estrified fatty acid (NEFA) levels in lake sturgeon upstream and downstream of the Mattagami River Generating station complex. NEFA levels, which are related to nutritional status, were significantly lower in lake sturgeon located downstream of the peaking facilities. Sheehan (1989) noted differences in the condition factors of lake sturgeon in these areas (Table 3).

Table 3: Condition factors for lake sturgeon, males and females combined, Moose River Basin.

Location	Date	Condition Factor	Source
Lower Groundhog/Mattagami River	July/August	0.54	Rossiter <i>et al.</i> (1995)
Lower Groundhog/Mattagami River	July/August	0.86	Nowak and Jessop (1987)
Little Long Headpond	June/July	0.76	Sheehan (1989)
Lower Mattagami River	June/July	0.68	..
Abitibi River	June/July	0.79	Gibson <i>et al.</i> (1985)
Upper Groundhog River	June	0.67	NEA (1992)
		0.62	
		0.78	NEA (1993)
		0.68	

Rossiter *et al.* (1995) hypothesize that a spartan food base is responsible for low rates of growth and low condition factors in Mattagami River lake sturgeon. The authors suggest that intraspecific competition for limited food resources upstream of the Little Long Generating station Headpond, is severe. Preferred food items are absent in leeward areas where extensive bark and wood fiber deposition covers natural substrates. BAR (1995) noted a decrease in the condition factor for sturgeon immediately downstream of Carmichael Falls Generating station. However, no change in the invertebrate community has been detected.

Table 4 summarizes the results of various investigators who have estimated sturgeon abundance and biomass in various rivers across the Basin. Gibson *et al.* (1985) and Nowak (1984) found that sturgeon densities in isolated headponds on the Abitibi and Mattagami Rivers, were less than one fish per hectare. Sturgeon captured in these areas were primarily adults. Density estimates for sturgeon in sections of the lower Groundhog and Mattagami Rivers and the Little Long Headpond range from 3.46 (Nowak and Hortiguella 1986) to 7.22 fish per hectare (Sheehan and McKinley 1992). Lake sturgeon captured in these areas were predominately adults. Nowak and MacRitchie (1984) estimated that adult and juvenile sturgeon represented approximately 27 percent of fish biomass in the Frederick House River. The results of NEA (1992, 1993), from a nursery area on the Groundhog River, suggest that sturgeon abundance is very high in such areas.

Table 4: Lake sturgeon population density and biomass estimates, Moose River Basin.

Location	Estimated Density (no/ha)	Estimated Density (no/km)	Estimated Biomass (kg/ha)	References
Frederick House River	1.27 1.89	8.9 13.3	13.5 22.3	Nowak and MacRitchie (1984)
Abitibi River	0.61 - 1.03	—	7.1	Gibson <i>et al.</i> (1985)
Mattagami River (headponds)	0.29 0.17	3.4 3.7	2.0 0.9	Nowak and Hortiguella (1986)
Mattagami/ Lower Groundhog Rivers	7.22	191.6	84.7	Nowak (1984)
Little Long Headpond	3.46	—	32.1	Sheehan and McKinley (1992)
Carmichael Falls/ Groundhog River	7.15 8.8	373.8 458.9	33.6 —	NEA (1992) NEA (1993)

Total annual mortality estimates of adult sturgeon on the lower Groundhog and Mattagami Rivers are similar, around 12 percent (**Table 5**). Threader and Brousseau (1986) estimated that total mortality for juvenile sturgeon in the Moose River was 13 percent. The total mortality for juvenile sturgeon captured in the vicinity of Carmichael Falls ranges between five and seven percent (NEA 1992, 1993).

Table 5: Lake sturgeon mortality rates, Moose River Basin.

Location	Estimated Total Mortality (%)	References
Lower Mattagami River	0.119	Sheehan and McKinley (1992)
Lower Groundhog/Mattagami River	0.115	Nowak and Jessop (1987)
Moose River	0.130	Threader and Brousseau (1986)
Lower Groundhog River	0.122	Nowak (1984)
Upper Groundhog River	0.050 0.070	NEA (1992) NEA (1993)

Investigators have utilized a variety of gear to capture lake sturgeon, the majority of which have proven ineffective. Electrofishing was tested by Sheehan and McKinley (1992), Sheehan (1989), NEA (1989), EAG (1980) and Lawson (1983) but failed to capture adults or juveniles. Fyke nets and trapnets have also been ineffective in capturing lake sturgeon (OMNR 1993, NEA 1989, Lawson 1983). Baited hooks have been utilized with some success by Threader and Brousseau (1986), EAG (1978, 1979) and were traditionally utilized to commercially harvest adult sturgeon. NEA (1989) reported that set lines were ineffective in capturing juvenile sturgeon.

Gillnets have been highly effective in capturing lake sturgeon. Catch rates have varied widely depending upon the investigators' choice of mesh sizes and the size range (e.g. juvenile vs. adult) of lake sturgeon inhabiting study locations (**Appendix I**).

Lake sturgeon angling has become increasingly popular over the past two decades. High yields have been recorded in sections of the lower Groundhog and Mattagami Rivers in areas where adults are known to congregate (**Table 6**). Lawson (1983) noted that the sturgeon biomass removed through angling exceeded commercial harvest. Kristmanson (1989) estimated that less than one percent of angling effort was directed at sturgeon in the Little Long Headpond, below the Groundhog and Mattagami Rivers and that 90 percent of all sturgeon caught by anglers were released. Near Carmichael Falls on the Groundhog River, an area inhabited primarily by juveniles, virtually all angled sturgeon are released (NEA 1993).

Table 6: Catch and harvest data for sturgeon angled in rivers, Moose River Basin (open water season).

Location (Reference)	Yield (kg/ha)	Yield (kg/km)	C.U.E. (no/hr)	Proportion of harvest (% no)
Lower Groundhog/Mattagami River (Lawson 1983)	2.52	66.9	0.05	—
Lower Groundhog/Mattagami River (Nowak 1984)	4.5	119.6	0.05	17.6
Lower Groundhog/ Mattagami River (Nowak 1984)	3.6	104.8	0.045	17.9

Subsistence fishing for sturgeon is known to occur in the Abitibi, Mattagami and Moose Rivers, however, harvests have never been quantified.

Historically, sturgeon were harvested commercially using baited hooks and large mesh gill nets. Sturgeon quotas of 0.2 to 0.28 kg per hectare were based upon production estimates derived by MacRitchie (1983). The minimum harvestable size was based upon length at first maturity and maximum size corresponded with mercury concentrations and human consumption guidelines. Commercial licences were cancelled in the 1970s and mid 1980s primarily due to infractions of licence conditions and reduced abundance of 'legal sized' sturgeon within the licenced areas. A review of historical commercial netting records (**Table 7**) indicates that prior to the development of biologically based quotas, mean harvests were very high in licenced areas. Nowak and Hortiguera (1986) and Payne (1987) hypothesized that growth overfishing contributed to the collapse of the lake sturgeon population in the upper Mattagami River.

Table 7: Commercial harvest data for lake sturgeon, Moose River Basin.

Location	Years	Mean Annual Harvest (kg)	Estimated Yield (kg/km)
Mattagami/Groundhog River	1961 - 71	2352	2.05
Upper Mattagami River	1927 - 63	432	0.74
	1970 - 80	35	0.06
Abitibi River	1935 - 82	527	0.21

Table 8 summarizes contaminant data for lake sturgeon. Mercury concentrations have rarely exceeded human consumption guidelines, however, very few data sets exist. Lake sturgeon in the lowlands appear to have slightly higher mercury concentrations than those found in the Clay Belt (**Figure 3**). Differences in lake sturgeon diets noted by McKinley *et al.* (1993) may influence mercury body burdens in these physiographic regions.

Table 8: Contaminant sampling data for lake sturgeon, Moose River Basin.

Site	Year	Mean [Hg] ppm	Mean [PCB] ppb	Sample Size (n)
Abitibi River	1981	0.45	150	89
	1984	0.95	—	10
	1990	0.20	—	5
Groundhog River	1976	0.17	—	31
	1983	0.11	107	20
	1994	0.20	—	20
Mattagami River	1977	0.14	48	8
	1991	0.10	—	20
Little Long Headpond	1991	0.13	—	19
Moose River	1978	0.43	—	15
	1979	0.46	—	26

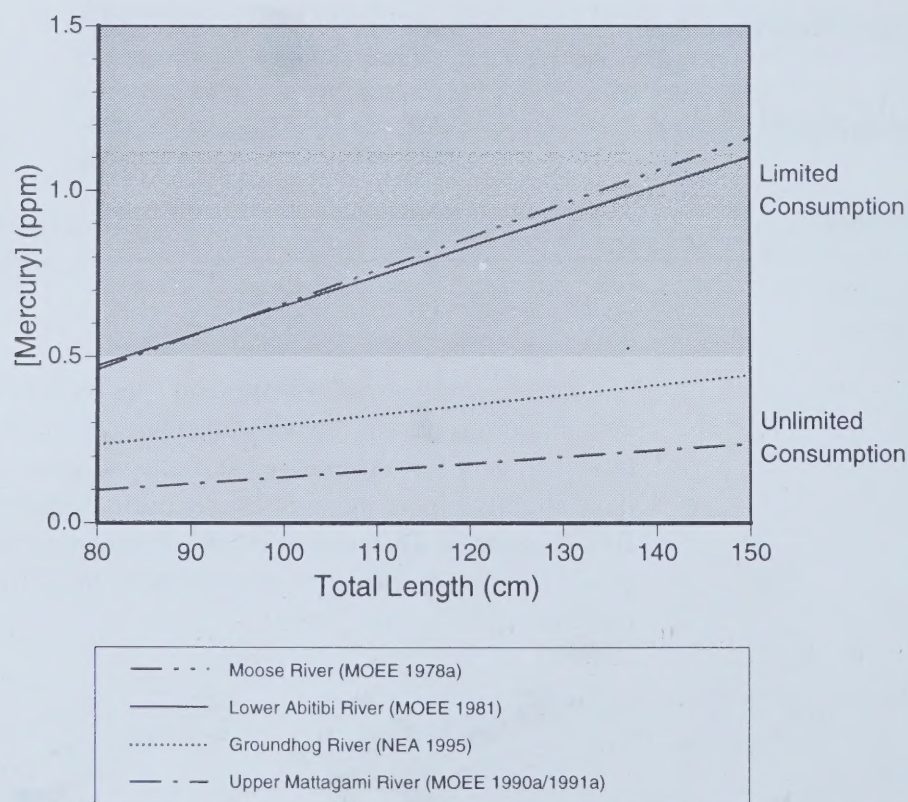
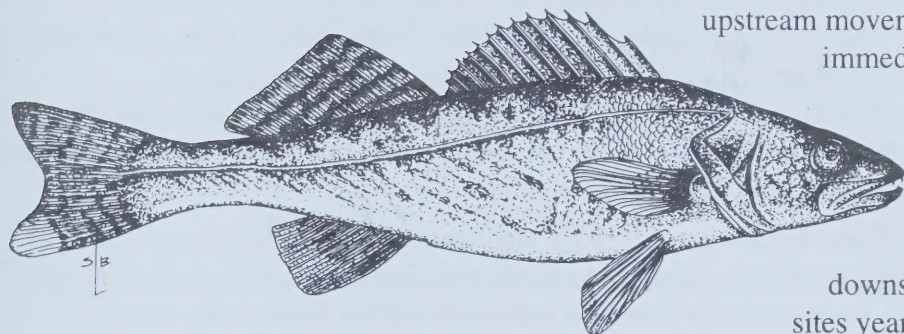


Figure 3: Mercury body burden correlations for lake sturgeon (*Acipenser fulvescens*) in selected locations, Moose River Basin.

3.0 WALLEYE (*STIZOSTEDION VITREUM*)

Walleye(*Stizostedion vitreum*) are distributed throughout the rivers of the Moose River Basin. Spawning activity has been observed at the base of many rapids and dams across the shield. Walleye tagged at spawning sites have been recaptured by anglers up to 50 km upstream and downstream (Hagen 1983, Nowak and MacRitchie 1984). McKinley *et al.* (1990) noted that radio tagged walleye commenced



upstream movement to spawning sites immediately prior to the spring freshet in the lower Mattagami River. Following the spawning run, approximately one half of radio tagged walleye remained within 15 km downstream of suspected spawning sites year round while others travelled more than 22 km downstream.

Spawning commences once water temperatures reach three to six degrees celcius and has occurred as late as May 20. Spawning walleye are most often observed over gravel and rubble substrates, in 0.5 to 1.0 m of water (Booth (1986), McMahon *et al.* 1984). Water velocities of 0.5 to 1.0 m per second in these areas provide a high degree of water circulation. Table 9 summarizes spawning times and locations in several rivers.

Table 9: Spawning observations for walleye in rivers of the Moose River Basin.

Date (s)	Water Temp. °(C)	Location Description	References
May 8 - 12	3 - 7	Cedar Rapids (upper Kapuskasing River)	Hagen (1983)
April 28 - May 16	6 - 10	Tailraces (Mattagami Generating Station complex)	Sheehan (1989)
May 12 - 20	—	Sandy Falls (upper Mattagami River)	MacRitchie (1983)
April 28 - May 5	6.3 - 9.5	C.P.R. trestle (Chapleau River)	Booth (1986)
April 26 - May 3	4.5 - 15	C.P.R. trestle (Chapleau River)	Booth <i>et al.</i> (1988)
April 26 - May 2	—	C.P.R. trestle (Chapleau River)	OMNR (1990)

The only detailed study of walleye egg incubation in the Basin, was completed by the Booth Aquatic Research Group on the Chapleau River (Booth 1986, Booth *et al.* 1988, BAR 1990). The authors estimate that hatching occurs between 198 and 225 degree days. In 1986, when water surface temperatures jumped rapidly from 7 to 18 C, hatching was completed in 16 days. During the incubation period walleye eggs are extremely vulnerable to environmental changes. The authors hypothesized that a two degree drop in water temperature following the walleye spawning run in 1990 resulted in high egg mortality.

Walleye in the Frederick House and Abitibi Rivers likely spawn shortly before sauger but may utilize some of the same areas. During MacRitchie's study of the Frederick House River fish community, he captured spent walleye with ripe sauger at several spawning sites (Nowak and MacRitchie 1984).

Upon hatching, walleye fry are carried downstream by river currents. High current velocities, particularly near reservoir outlets, can result in high fry mortality (Groen and Schroeder 1978). Walleye fry feed predominately upon microcrustaceans and may compete with other planktivores during their early life history (Colby *et al.* 1979). Potential competitors include goldeye and sauger in the eastern portion of the Basin and burbot throughout the Basin.

YOY walleye have been captured, primarily in seine nets, over a variety of bottom types (**Table 10**). Most catch records indicate a preference for low to moderate flows. YOY appear to remain in main river channels near the shore. Inflowing creeks and tributaries may represent important sources of food.

Juvenile habitat requirements are thought to be similar to those of adult walleye (Colby *et al.* 1979, McMahon *et al.* 1984). Juvenile and adult walleye have been captured together in many netting projects in the Basin.

Instream cover is a habitat variable considered to be important to adult and juvenile walleye. It can be described both in terms of water transparency and physical shelter (McMahon *et al.* 1984). Turbid water conditions in many rivers in the Basin likely provide refuge from high light intensities. Feeding success may be reduced in very turbid waters (Ryder 1977). Instream cover provided by boulders and submerged debris is important in providing refuge from high flows. Physical shelter within river channels of the Moose River Basin is provided by islands, pools and back eddies, all of which provide low flow habitat. This is supported by observations made in a number of population assessment studies (**Table 10**).

Table 10: Walleye river habitat utilization, Moose River Basin.

Date	Location Description	References
I. Adults/Juveniles		
May	pools/8 m depth, wide areas, mouths of creeks, soft bottom substrates, low flows	NEA (1992)
May/June	wide areas, pools/7 - 9 m depths near foot of rapids, gravel/sand bottoms	NEA (1989)
June	pools, back eddies near rapids, main channel troughs, bedrock/sand bottoms	NEA (1993)
July	wide areas, back eddies near rapids, 3 to 4 m depths), sand bottoms	CIMA (1991)
July/Aug.	pools/8 m depth, shallows, back eddies, channel troughs, immediately below rapids, variety of bottom types	NEA (1992)
II. Young-of-the-Year		
June	edge of main channel trough, gravel/ sand bottom, moderate current, moderate emergent vegetation, 1.0 m depth	OMNR (1983b)
	channel edge, muck/detritus bottom, slow current (0.08 m/sec), sparse instream cover, 0.6 m depth	OMNR (1983b)
July	channel edge (inside bank), rubble/ detritus/sand/clay bottoms, slow currents, sparse instream cover, 0.6 - 2.0 m depth	OMNR (1983b)
	wide areas below riffles, mouths of inflowing creeks	CIMA (1991)

Very few habitat utilization observations exist for walleye in the lowland portions of rivers. A study of the lower Abitibi River (EAG 1980) suggests that walleye are found in the greatest numbers near islands and at the mouths of large inflowing tributaries. This study also documents adult utilization of small creeks.

There have been no studies of walleye habitat utilization in headponds in the Basin. In these lake-like conditions it is assumed that walleye exhibit many of the same behavioral patterns and habitat preferences as lacustrine populations, although they may require riverine conditions at critical stages in their life history (e.g. spawning).

Hydroelectric facilities located throughout the Basin impact walleye spawning success and behavior. Spawning activity has been documented

in tailraces and may occur immediately downstream of peaking facilities (Sheehan 1989). As long as discharges are maintained below hydroelectric facilities throughout the spring freshet, walleye eggs should not be in danger of desiccation (Carson *et al.* 1991). Peaking operations may expose walleye spawning shoals below facilities and managers should be aware of this potential danger where peaking flows commence prior to mid-June.

Log driving on the Kapuskasing and Mattagami Rivers may have had a detrimental effect on walleye habitat. Although no bark deposits have been identified at suspected spawning sites, floating logs may have contributed to scour in these areas over time and possibly disrupted spawning activity or hatching success in the past. Extensive accumulations of bark have been documented in areas of low flow on the Kapsuskasing (ESP 1993) and Mattagami (A. Rossiter pers. comm.) rivers, covering natural substrate and periodically causing localized anoxic conditions. Extensive scouring and erosion has taken place along river banks, particularly at log landing areas. These conditions may affect walleye fry survival by limiting nursery habitat and food sources.

There have been no specific studies undertaken to describe walleye diet in large rivers in the Basin, however, a number of investigators have made observations regarding stomach contents. The following food items are listed in order of most to least frequently reported: crayfish, mayfly larvae, stonefly larvae, dragonfly larvae, walleye, YOY sturgeon, northern pike, longnose dace, and johnny darters (ESP 1993, NEA 1993, Sheehan 1989, EAG 1980). Although never quantitatively described, it appears that invertebrates make up the most important component of walleye diets. Walleye feed by sight, usually near or at the bottom in shallow water (Colby *et al.* 1979). Feeding activity is believed to be greatest during the night and early morning hours. McKinley *et al.* (1990) found that walleye in the lower Mattagami were most active between 1:00 and 8:00 a.m. In more turbid waters such as the Frederick House and Abitibi Rivers it is possible that feeding occurs throughout the day.

Appendix II summarizes walleye catch rates from various assessment projects. Experimental gillnets, the most frequently used gear, have generally succeeded in catching large numbers of walleye in May and June (**Figure 4**). During this period, walleye tend to concentrate in discrete areas (e.g. proximate to spawning areas). Catch records from trapnetting projects also suggest that catch rates are highest during or shortly after the spring spawning season. Walleye capture rates in both trapnets and gillnets decrease during autumn months in both riverine and headpond habitat. Fyke nets (CIMA 1991, NEA 1989) and hoop nets (Booth 1986) have proven ineffective for capturing walleye in rivers year-round.

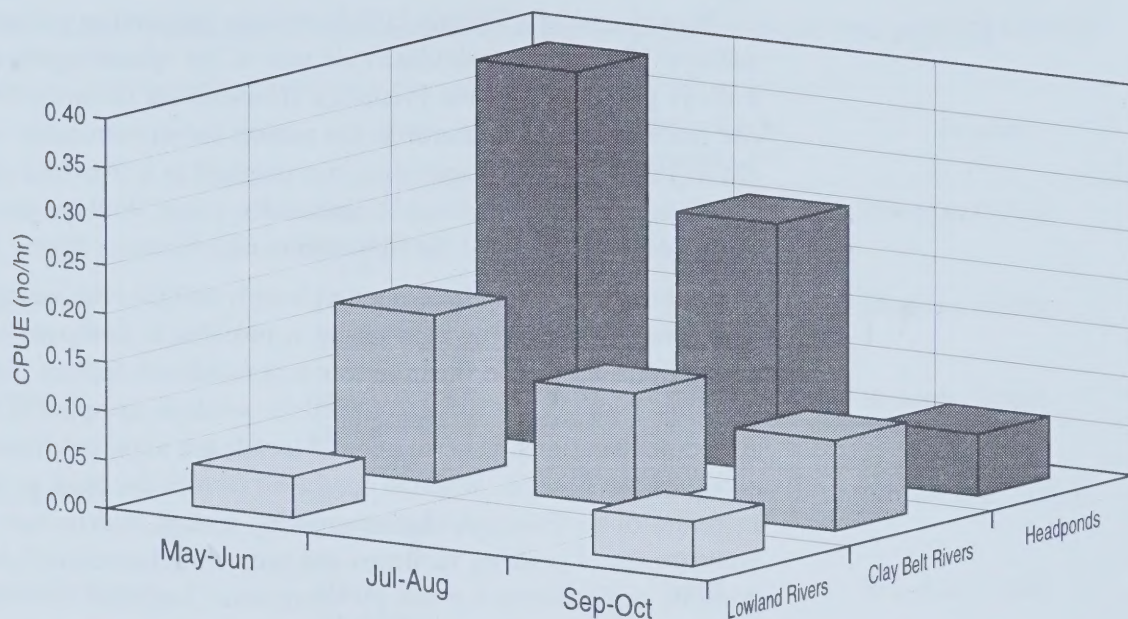


Figure 4: Seasonal catch rates (CPUE) for walleye (*Stizostedion vitreum*) in riverine and headpond habitats using 25 to 127 mm gillnets (from Appendix II).

Walleye mortalities during gillnetting studies vary with the duration of sets and time of year (Table 11). High mortality during spring netting is attributable to high flows which put additional stress on entangled walleye. During summer months, high water temperatures likely become a factor in walleye mortality. Mortalities dramatically decrease in September and October when flows and water temperatures are generally low.

Table 11: Mortality of walleye captured during river gillnetting studies within the Moose River Basin.

Investigator	Mean Duration of Sets (hr)	Percent Mortality				
		June	July	Aug.	Sept.	Oct.
NEA (1992)	17	53.8	—	52.3	—	0.0
McCrudden (1982)	4	—	80.0	18.7	0.0	—
Seyler (1994)	3	43.3	—	47.0	9.5	—
	24	—	—	—	63.6	—

Nowak and MacRitchie (1984) provide population estimates for river walleye. The authors calculated the size of the spawning segment of a walleye population on the Frederick House River in successive years. They cite fluctuating temperatures as the reason for an extremely weak spawning run in 1983. The weak spawning run resulted in a five-fold difference in population estimates between consecutive years. Walleye made up an estimated 3.2 percent of the fish community biomass during this study.

Although few length-at-age and length-weight relationships have been calculated from existing data sets, it is possible to compare walleye populations across the Basin in terms of condition factors. Table 12 contains condition factors calculated for walleye sampled in May and June at various locations. Several general trends are apparent from the limited data base we possess. Walleye condition factors decrease in the northern extremes of the Basin. A shorter growing season, hostile conditions downstream of peaking facilities and prey abundance/availability are possible explanations for this phenomenon. Condition factors also seem to be lower in rivers on the eastern edge of the Basin, where waters are most turbid. Walleye foraging behavior may be inhibited somewhat in these waters. Walleye condition in the Frederick House and Abitibi Rivers may also be affected by interspecific competition with sauger. It has been suggested that highly turbid conditions may favor sauger (Leach *et al.* 1977, Schupp and Macins 1977). Finally, within the Mattagami Hydroelectric Complex, walleye condition decreases in successive headponds, over a relatively short distance (Sheehan 1989). This decrease may be indicative of a cumulative effect on the physical health of walleye, caused by the impoundments.

In all of the angler creels completed on river systems in the Basin, walleye have consistently been the most sought after species (Kristmanson 1989, Nowak 1984, MacRitchie 1984b, Lawson 1983). Table 13 summarizes walleye harvest data. The highest documented catch and harvest rates were recorded in the Little Long Headpond and a section of the Mattagami River directly associated with it (Kristmanson 1989).

No cases of walleye overfishing have been documented by river managers. MacRitchie (1984b) reports that following a later than usual spawning run, walleye on the Upper Mattagami stayed near spawning sites for several weeks. During this period they were extremely vulnerable to angling. Walleye angling mortality was estimated to be 28.5 percent. Angling mortality rates of this magnitude may put walleye populations at risk of overexploitation (OMNR 1983a).

Walleye have been sampled as part of the sport fish contaminant monitoring program more frequently than any other fish species in the Basin. Appendix III contains 56 records of sampling projects carried out since 1971. Although elevated levels of PCBs and pesticides have not been detected in walleye, there are numerous sites and sections of river where

Table 12: Condition factors, males and females combined, for walleye in spawning and postspawning condition, Moose River Basin.

Location	Date	Condition Factor (100.wg/length ³)	Source
Little Long Headpond	May (spawning)	1.583	Sheehan (1989)
Harmon Headpond	May (spawning)	1.325	Sheehan (1989)
Kipling Headpond	May (spawning)	1.253	Sheehan (1989)
Island Falls Headpond	June (post spawning)	1.186	Gibson <i>et al.</i> (1984)
Lower Mattagami (lowlands)	May (spawning)	1.187	Sheehan (1989)
Upper Kapuskasing River	May (spawning)	1.266	Hagen (1983)
Upper Mattagami	May (spawning)	1.223	MacRitchie (1984a)
Frederick House River	May (spawning)	1.095 1.085	MacRitchie (1984a)
Chapleau River	April (spawning)	1.240	OMNR (1990a)
	May (post spawning)	1.19	Booth (1986)
Onakawana, Abitibi River	June (post spawning)	1.048	EAG (1980)
Moose River	June (post spawning)	1.069	OMNR (1987)
Carmichael Falls Groundhog River	June (post spawning)	1.159	NEA (1993)

Table 13: Catch and harvest data for walleye angled in rivers, Moose River Basin (open water season).

Location (reference)	Yield (kg/ha)	Yield (kg/km)	CPUE (no/hr)	HUE (no/hr)	Proportion of Harvest (%)
Groundhog River (Nowak 1984)	0.86	22.8	0.22	0.17	67.5
Groundhog River (Nowak 1984)	0.64	16.8	0.16	0.13	70.4
Kapuskasing River (Lawson 1983)	—	11.9	0.17	0.13	69.8
Little Long Headpond (Kristmanson 1989)	0.07	—	0.27	0.21	92.2
Mattagami River (Ibid. 1989)	—	57.9	0.59	0.41	88.6
Upper Mattagami River (MacRitchie 1984b)	—	—	0.07	0.06	48.0

mercury concentrations in walleye flesh exceed Provincial consumption guidelines. According to historical records these areas include storage and mainstem reservoirs on the Mattagami and Abitibi River watersheds, and the Kapuskasing River. Kristmanson (1989) estimated that 50 percent of all walleye harvested by anglers from the Mattagami River and Generating station complex exceeded consumption guidelines related to mercury body burdens. Figure 5 illustrates mercury concentration-length relationships for walleye from selected sites.

Sites have rarely been sampled more than once as part of the Sport Fish Contaminant Monitoring Program so the database rarely lends itself to trend-through time analyses. At the Carmichael Falls hydroelectric Generating station on the Groundhog River mercury concentrations in walleye have increased over the five years the facility has been in place (NEA 1993). This trend is most evident in walleye immediately downstream of the facility and has been attributed to upstream food sources originating in the newly created headpond.

Walleye are being used as sentinel species as part of environmental effects monitoring programs near pulp and paper mills on the Kapuskasing and Abitibi Rivers (BAR 1993, BAR 1995). Walleye were selected because they are abundant and spend much of their life cycle as residents within mill effluent exposure zones. As a spring spawner, the impact of overwintering within exposure zones should be detectable (Environment Canada 1993). Growth, reproductive condition, energy stores and population age structure are being monitored in order to assess environmental quality upstream and below mill locations.

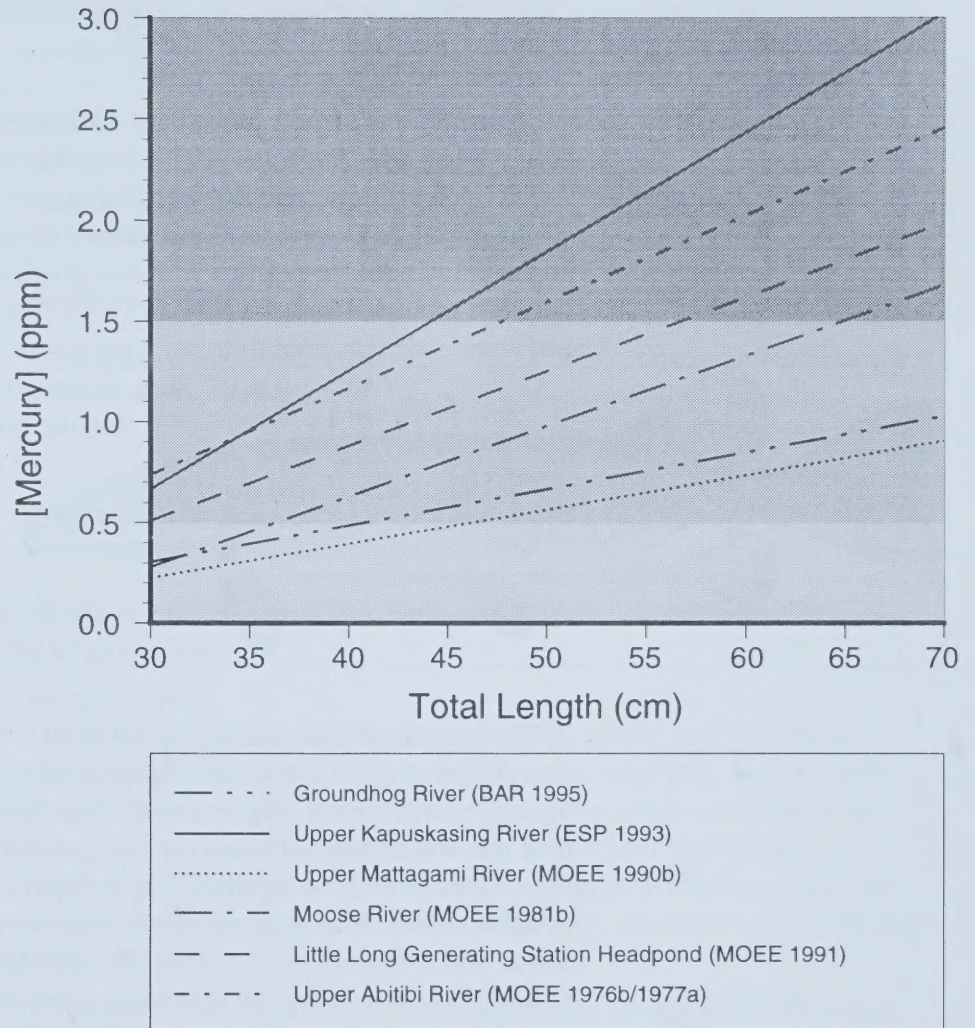


Figure 5: Mercury body burden correlations for walleye in selected locations, Moose River Basin.

4.0 NORTHERN PIKE (*ESOX LUCIUS*)

Northern pike (*Esox lucius*) are distributed throughout the Moose River Basin. Scott and Crossman (1973) note that northern pike are usually found in clear, slow, heavily vegetated rivers. Pike are not adapted to life in strong currents. They tend to utilize low velocity habitats, e.g. back waters and shallow pools in reaches with low gradients to permit movement between preferred habitats (Inskip 1982). The tightly contained channels and steep-sided channel troughs, common to much of the Shield and the

Clay Belt, do not provide an abundance of slow flowing refugia, nor are they conducive to aquatic macrophyte growth.

Considering this general channel morphology, river conditions can be described

as marginal, at best, for this species

according to accepted habitat models.



Northern pike spawning activity has been documented at several locations (**Table 14**). Within main river channels, pike utilize shallow, slow flowing areas of river conducive to aquatic macrophyte presence. Higher order, slow flowing tributaries and creeks may provide suitable alternatives for spawning. Spawning activity has been noted as early as April 30 (NEA 1989) and as late as May 24 (OMNR 1983). Pike eggs are often attached to vegetation and submerged debris and generally hatch within 14 days (Scott and Crossman 1973). During this period they are extremely susceptible to water level drawdowns experienced in headponds, particularly in the case of peaking operations.

Nowak and MacRitchie (1984) and MacRitchie (1984b) reported that pike congregate in localized areas to spawn and widely disperse immediately following spawning in the Frederick House and Mattagami Rivers. These observations are based upon index netting results and angler catches over a 64 km section of the Frederick House and 39 km section of the Mattagami Rivers. MacRitchie (1983) noted that following dispersal, pike were found in low numbers in very localized areas and tended to utilize these areas in successive years.

A review of catch records from index netting projects indicates that adult northern pike are most often captured in shallow back eddies and wide areas of rivers where flows are low (**Table 15**). Substrates in these areas usually consist of sand, silt or organic material. They are also commonly found near the mouths of small, inflowing creeks which may provide refuge. As flows decrease in the summer, pike become more common in main channel troughs.

Table 14: Spawning observations for northern pike in various rivers within the Moose River Basin.

Date (s)	Water Temp. °(C)	Location Description	References
April 30 - May 5	7	Boulder shoal, back eddy at base of Carmichael Falls (Groundhog River)	NEA (1989)
May 4, 5	5 to 6	Carmichael Falls	NEA (1988)
May 6 - May 17	3 to 6	Back eddies, widenings, low flows (Frederick House River)	Nowak and MacRitchie (1984)
May 16 - May 24	—	Back bays below Sandy Falls, and tributaries Kam. Creek, Waterhen Creek (Mattagami River)	MacRitchie (1984b)
May 2 - May 15	6 to 10	Shallows, Harmon headpond (Mattagami River)	Sheehan (1989)

According to Scott and Crossman (1973), young pike remain in shallow spawning areas for several weeks after hatching. Holland and Huston (1984) reported that YOY northern pike were associated with areas of extensive submerged vegetation throughout the summer. Young-of-the-year northern pike have been found in shallow, protected areas during the early summer and in main river channels later in the year (Table 15).

Habitat suitability models developed by the United States Fish and Wildlife Service list many habitat variables considered important to northern pike (Inskip 1982). Habitat variables which may represent limiting factors in northern rivers include the availability and accessibility of suitable spawning and nursery habitat, water level changes during embryo and fry stages, especially in headponds, availability of backwater or sluggish water areas and stream gradient as it relates to flow. Suitability criteria for these variables have yet to be developed for northern Ontario rivers.

YOY northern pike are plankivorous for a short period following hatching, after which they become opportunistic feeders, switching to a diet of invertebrates (Scott and Crossman 1973). As YOY northern pike grow, fish become a major component of their diet (Franklin and Smith 1963; Holland and Huston 1984). The most common objects found in pike stomachs in rivers, in the Basin have been crayfish and dragonfly nymphs (ESP 1993, NES 1989, EAG 1980, OMNR 1984). Other food items found less frequently have included burbot (EAG 1980, OMNR 1984),

Table 15: Northern pike river habitat utilization observations, Moose River Basin.

Date	Location Description	Reference
I. Adults/Juveniles		
May	wide areas, near shore, gravel/sand bottom, 1 - 3 m depth; edge of pool, 5 m depth	NEA (1992)
May/June	back bays/eddies, low flows, clay/sand/silt bottoms, 1 - 4 m depth	NEA (1989)
June	shallows, gravel/sand bottoms; wide areas, mouths of creeks	NES (1993)
July	shallow back eddies, wide areas, creek mouths, low flows	CIMA (1991)
July/August	mouths of creeks, shallow back eddies, main channel troughs	NEA (1992)
October	back eddies, wide areas, mouths of creeks	NES (1993)
II. Young-of-the-Year		
June	mouths of small creeks, detritus bottom, sparse emergent vegetation, 1 m depth	OMNR (1983b)
July	back eddies, extensive shallow areas, low flows, vegetation present	CIMA (1991)
	main channel trough, 3 m depth and edge (0.6 m), clay/boulder/muck bottom, low flows, no vegetation present	OMNR (1983b)
August	main channel margin, 1 m depth, low flows, detritus bottom, sparse emergent vegetation	OMNR (1983b)

catostomids and brook trout (NES 1989, OMNR 1984). Northern pike are day active, hunting by sight. It is unknown if high turbidity within Clay Belt rivers has a direct impact upon the foraging efficiency of northern pike in these areas. Shallow areas with instream cover, e.g. submerged vegetation or debris, are thought to be important in providing hunting cover and, for small pike, refuge from predation (Inskip 1982).

MacRitchie (1983) estimated that northern pike made up between 1.5 and 3.0 percent of large fish biomass, 0.6 to 2.3 percent by number, in the Frederick House River. He found that pike abundance was low relative to other fish species, approximately four to eight individuals per kilometre of river. MacRitchie (1984b) estimated that pike made up approximately 7.3 percent by number, of the large fish population on a Clay Belt section of the Mattagami River. Northern pike abundance in this section of the Mattagami River was estimated to be nine to ten individuals per kilometer.

Catch rates for northern pike from index netting projects across the Basin suggest that pike abundance is highest in headpond areas and in riverine reaches associated with headponds (**Appendix IV**). Sheehan (1989) examined fish communities in each of four headponds making up the Mattagami Generating Station complex. He found that northern pike made up a large component of the fish communities within the Harmon and Little Long headponds, which contain extensive shallow, low flow areas. Sheehan noted the presence of macrophyte beds and submerged shoreline vegetation and documented the presence of YOY pike in both headponds. The ability of northern pike to successfully colonize these areas is likely related to several factors including headpond morphology and water level regimes.

Figure 6 illustrates mean catch rates for northern pike in headpond and riverine environments. The mean CPUE within mainstem headponds is relatively high year round. High CPUEs in riverine reaches during May and June are partly attributable to high susceptibility of northern pike to gillnets set in spawning areas. Capture rates generally decrease during July and August, following post-spawning dispersal, and increase again in September and October. Low flows during autumn months may permit northern pike to range more extensively throughout river channels.

Creation of the Little Long headpond (7167 ha) has undoubtedly benefited northern pike populations in the lower Kapuskasing, Groundhog and Mattagami Rivers. Little Long Generating Station resulted in the formation of extensive marsh areas, which are uncommon along mainstem Clay Belt rivers, and which appear to be well suited to this species' life history. Not all headponds appear to provide optimal northern pike habitat. Pike abundance is low in small isolated headponds such as Smoky Falls Generating Station and Kipling Generating Station, both of

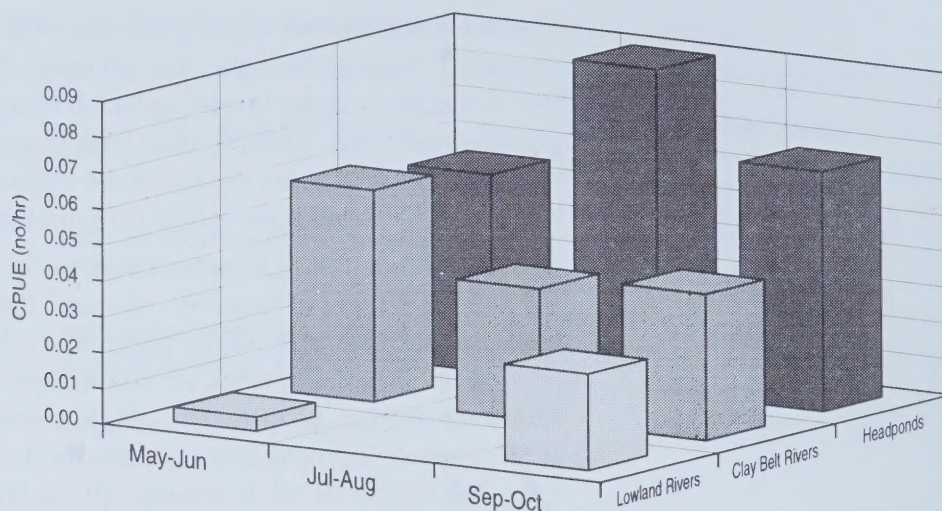


Figure 6: Seasonal catch rates (CPUE) for northern pike (*Esox lucius*) in headpond and riverine habitats, using 25 to 127 mm mesh gillnets (from Appendix IV).

which are peaking operations (Sheehan 1989). Northern pike abundance in the vicinity of Carmichael Falls Generating Station, a run of the river facility, has not changed five years following construction (BAR 1995). The relationship between water level fluctuations and aquatic macrophytes may be the major determinant of northern pike abundance and the sustainability of pike populations in headponds. Research conducted elsewhere has shown that macrophyte distribution and abundance influence habitat utilization in reservoirs (Cook and Bergerson 1988).

On the upper Kapuskasing River, decades of log driving activities have resulted in scouring of littoral areas, decreasing channel roughness and removing most aquatic vegetation (ESP 1993). The authors believe it is possible to increase northern pike habitat and productivity in these sections of river by constructing shoals and bars within the main channel thus creating low flow littoral areas, conducive to natural revegetation. Holland and Huston (1984) demonstrated the importance of maintaining beds of emergent and submergent vegetation in the management of northern pike spawning and nursery habitat.

There has been very little assessment of northern pike in the lowland areas of the Basin. Areas immediately downstream of hydroelectric peaking operations on the Abitibi and Mattagami Rivers appear to represent rather harsh conditions for pike. Sheehan (1989) found very little suitable northern pike habitat below Kipling Generating Station. Studies near Onakawana, on the lower Abitibi River, also allude to a shortage of suitable pike habitat (EAG 1980). Inflowing tributaries may represent

important refuge and nursery areas in the lowlands. The suitability of these areas may be dependent on the moderating influence of beaver activity (EAG 1980). In the lower Moose River, where the effects of peaking flows are dampened out by unregulated inflows, extensive floodplain vegetation and instream structure exists which may benefit the species.

In the upper portions of the Basin, northern pike populations and optimal habitat are maintained in headwater storage reservoirs such as Horwood Lake (Groundhog River), Ivanhoe Lake (Ivanhoe River) and Minisinakwa Lake (Mattagami River). Along unregulated rivers on the shield, such as the Chapleau/Nemogosenda River system, chains of natural mainstem lakes provide pike populations with suitable habitat. Several large mainstem marshes also occur at flat spots along the shield, such as at Peterbell (Missinaibi River) and near Kapuskasing Lake (Kapuskasing River) which also likely contribute to pike production.

Very little angler harvest data has been collected for northern pike although it appears that this species makes up a large proportion of the reported harvest from rivers. Nowak and Jessop (1987) report that pike made up between 62 and 78 percent of harvested fish by number between 1982 and 1984 on the lower Groundhog and Mattagami Rivers. MacRitchie (1984b) reported that northern pike made up 62 percent of the sport fish catch and 46 percent of the harvest on the Mattagami River. In a creel survey of the Mattagami Generating station complex and River, Kristmanson (1989) reported that northern pike made up 19 percent of the total sport fish catch from the river and 36 percent of the catch in headpond areas. Catch (CPUE) and harvest (HUE) rates for pike across the entire creel area were 0.365 and 0.058 fish per hour, respectively. Kristmanson noted that the vast majority of anglers, 78 percent, prefer walleye over northern pike. Northern pike yields from the creels noted above range from 0.44 to 0.99 kg per hectare.

Researchers have employed a variety of gears to capture northern pike, with variable success. Shallow water seining appears to be the most effective method of capturing young northern pike. The use of fyke nets (CIMA 1991, NEA 1989), hoop nets (BAR 1986) and boat electroshockers (Lawson 1983, Sheehan 1989) to catch adults has proven unsuccessful. Trap nets have worked most efficiently in the spring where pike tend to congregate to spawn (**Appendix IV**). Trapnets are extremely awkward to use in river channels. Even low currents affect net placement which undoubtedly reduces capture efficiency. The use of gillnets is by far, the most effective means of capturing pike year round. Capture efficiency can be improved by targeting habitat types summarized in Table 15, at times of the year when preferred habitat is limited by physical conditions, e.g. high flows. Where mortality is a concern, short set

gillnetting may be a preferred, labor intensive, alternative to overnight sets. Seyler (1997), McCrudden (1982) and NEA (1989) utilized short sets throughout the open water season resulting very low mortality rates.

Appendix V summarizes results from 47 collections of northern pike used for contaminant analysis. Generally, pike from watersheds with the highest degree of instream development have elevated mercury body burdens. This is reflected in samples from almost all storage reservoirs, mainstem headponds and associated river channels.

Due to difficulties associated with capturing large numbers of northern pike, very little contaminant data exists for rivers. The majority of data sets describe mercury body burden relationships in headponds and reservoirs where northern pike are more abundant. Generally, correlations between mercury concentration and fish length tend to be weaker in northern pike than in walleye captured in similar locations.

The highest levels of mercury have been found in northern pike in the upper Abitibi and Groundhog Rivers and in several mainstem hydroelectric headponds along the Mattagami and Abitibi Rivers (**Figure 7**).

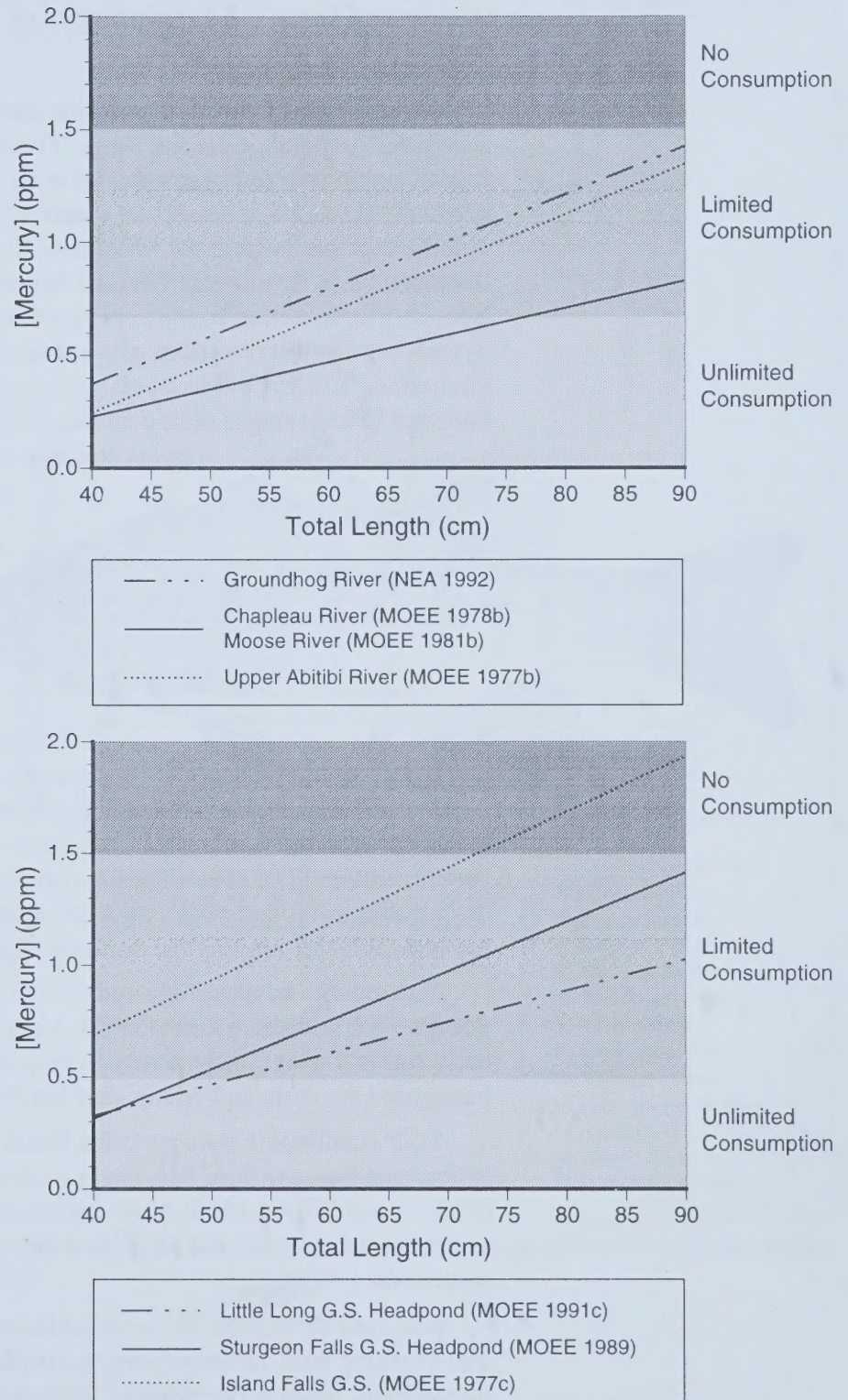
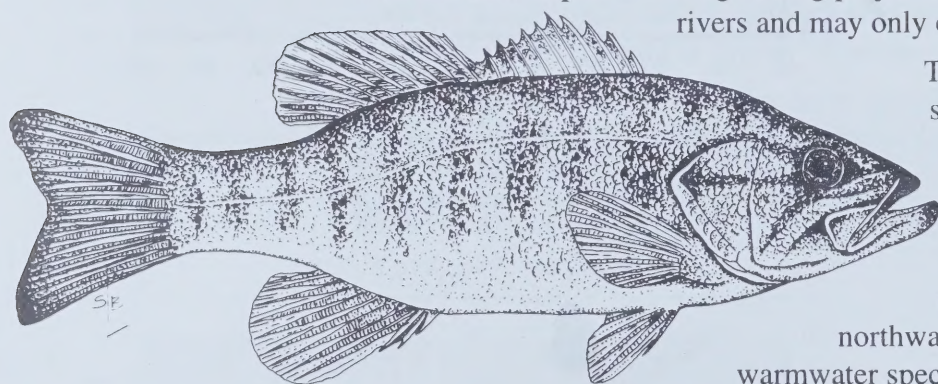


Figure 7: Mercury body burden correlations for northern pike in selected locations, Moose River Basin.

5.0 SMALLMOUTH BASS (*MICROPTERUS DOLOMIEUI*)

We know very little about riverine smallmouth bass (*Micropterus dolomieu*) populations in the Basin. This non-native species has been introduced to selected headwater lakes on the shield since the 1920s and gradually spread to several river systems. Their most successful colonization has been in the Missinaibi River where they have been documented as far north as Thunder House Falls (**Figure 8**). Smallmouth bass are also abundant in the upper portions of the Mattagami River system and adults are periodically captured in the Chapleau and Groundhog Rivers (Dawson pers. comm. OMNR 1994). Smallmouth bass have not been captured during netting projects carried out on the latter two rivers and may only occur in localized sections.



The occurrence of smallmouth bass in the Moose River Basin represents the most northern latitude of their range (Scott and Crossman 1973). Continued

northward expansion of this warmwater species is likely prevented by harsh climatic and physical conditions experienced in the Hudson Bay Lowlands which may affect hatching success and/or YOY overwintering survival. Shuter and Post (1990) suggest that overwinter starvation mortality of young smallmouth bass is the critical factor limiting the northern distribution of this species.

Smallmouth bass ecology and habitat preferences have been well documented elsewhere across North America. They spawn in late spring/early summer over clean gravel or sandy substrates in shallow water. Male bass guard the nests and young after hatching.

YOY smallmouth bass are often found near instream cover such as submerged logs and boulders, likely to avoid detection by predators (Walters and Wilson 1996). Lobb and Orth (1991) reported that young smallmouth bass preferred shallow water and slow currents along river shorelines.

Bass feed throughout the water column. Plankton are important in the diet of young bass, however insects, crayfish and small fish make up increasingly larger proportions of the species' diet as they grow (Scott and Crossman 1973).

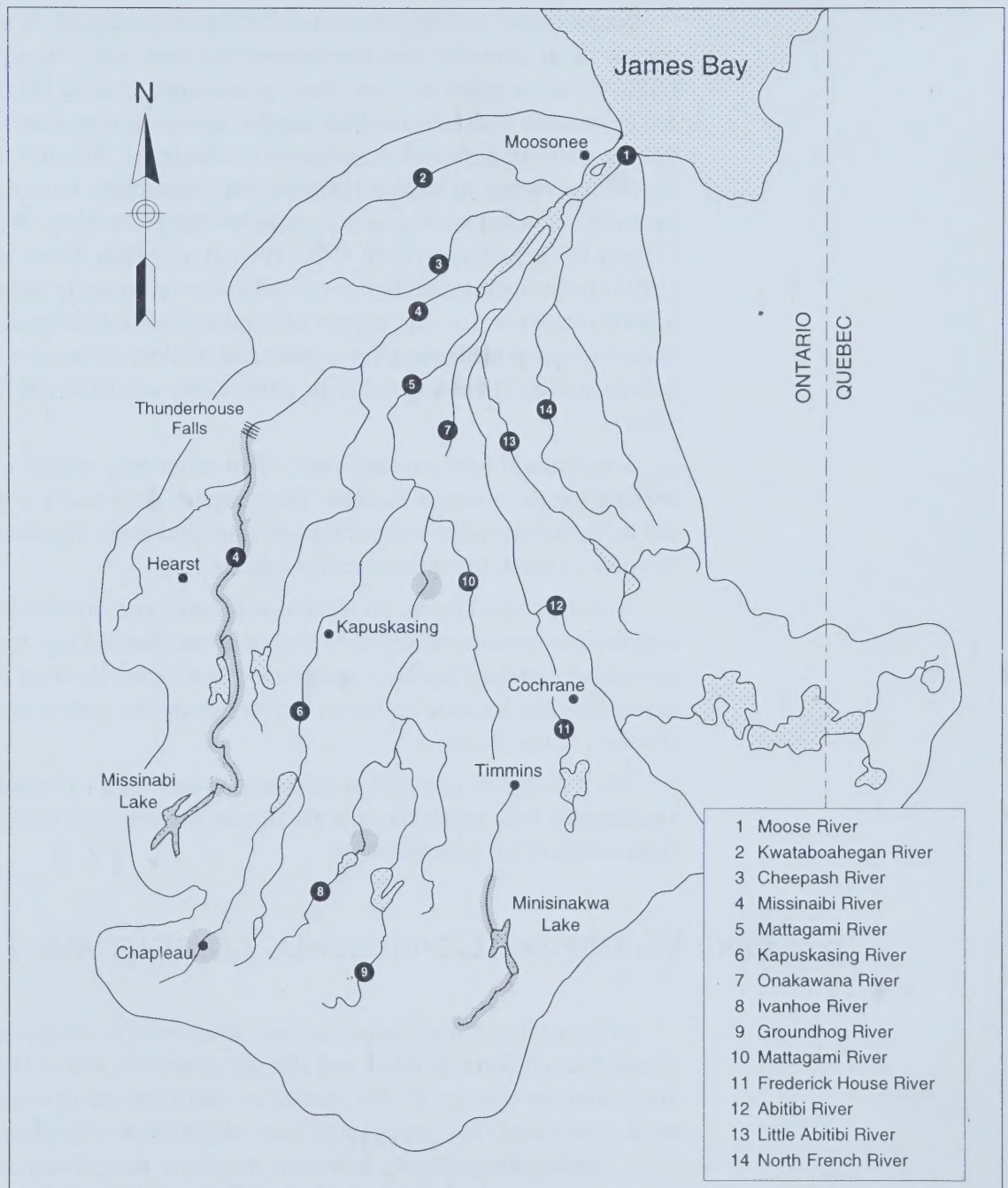


Figure 8: Documented distribution of smallmouth bass (*Micropterus dolomieu*) within the Moose River Basin.

Smith (1994) summarized adult habitat requirements in a literature review of smallmouth bass movements in rivers. Adult bass require relatively clear water and low flows year round. During the summer they are associated with intermediate depths, however, they may retreat to deeper water (e.g. pools) as temperatures increase. Because they have been found in a variety of habitat types several researchers have designated both juvenile and adult smallmouth bass as habitat generalists (Walters and Wilson 1996, Lobb and Orth 1991, Bain *et al.* 1988). Sowa and Rebeni (1995) have suggested that habitat utilization is strongly related to crayfish habitat requirements (e.g. coarse substrates). Adult smallmouth bass have shown a strong preference for cobble and boulder substrates in a number of habitat studies (Leonard and Orth 1988, Lobb and Orth 1991, Paragamian 1981).

Smallmouth bass are sedentary, often remaining within a very small area during the summer months. They require deep pools, e.g. greater than 3.0 m, to successfully overwinter and may undertake significant movement in order to reach these areas in the autumn.

Although appropriate physical conditions exist, smallmouth distribution remains spotty across most of the Basin. High turbidity levels, particularly in the Clay Belt, may be a major factor limiting the species' ability to colonize new sections of rivers along the central and southern portions of the Basin.

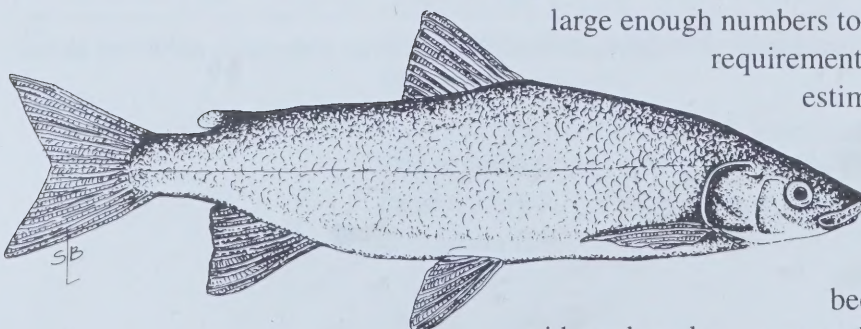
No meristic or population information has been collected for riverine smallmouth bass populations in the Basin. Smallmouth bass have never been sampled for contaminants.

6.0 LAKE WHITEFISH (*CORREGONUS CLUPEAFORMIS*)

Self-sustaining populations of lake whitefish (*Corregonus clupeaformis*) occur in lakes and storage reservoirs across the Moose River Basin and the ecology of this species in lacustrine environments is fairly well understood. The presence of lake whitefish in rivers has also been widely documented, however, they have never been captured in large enough numbers to define life history and habitat requirements (**Figure 9**). MacRitchie (1983)

estimated that lake whitefish made up less than 0.1 percent of fish biomass within a 14 km section of the Frederick House River.

Generally, lake whitefish have been found most frequently where rapids and pools occur together (Nowak and MacRitchie 1984,



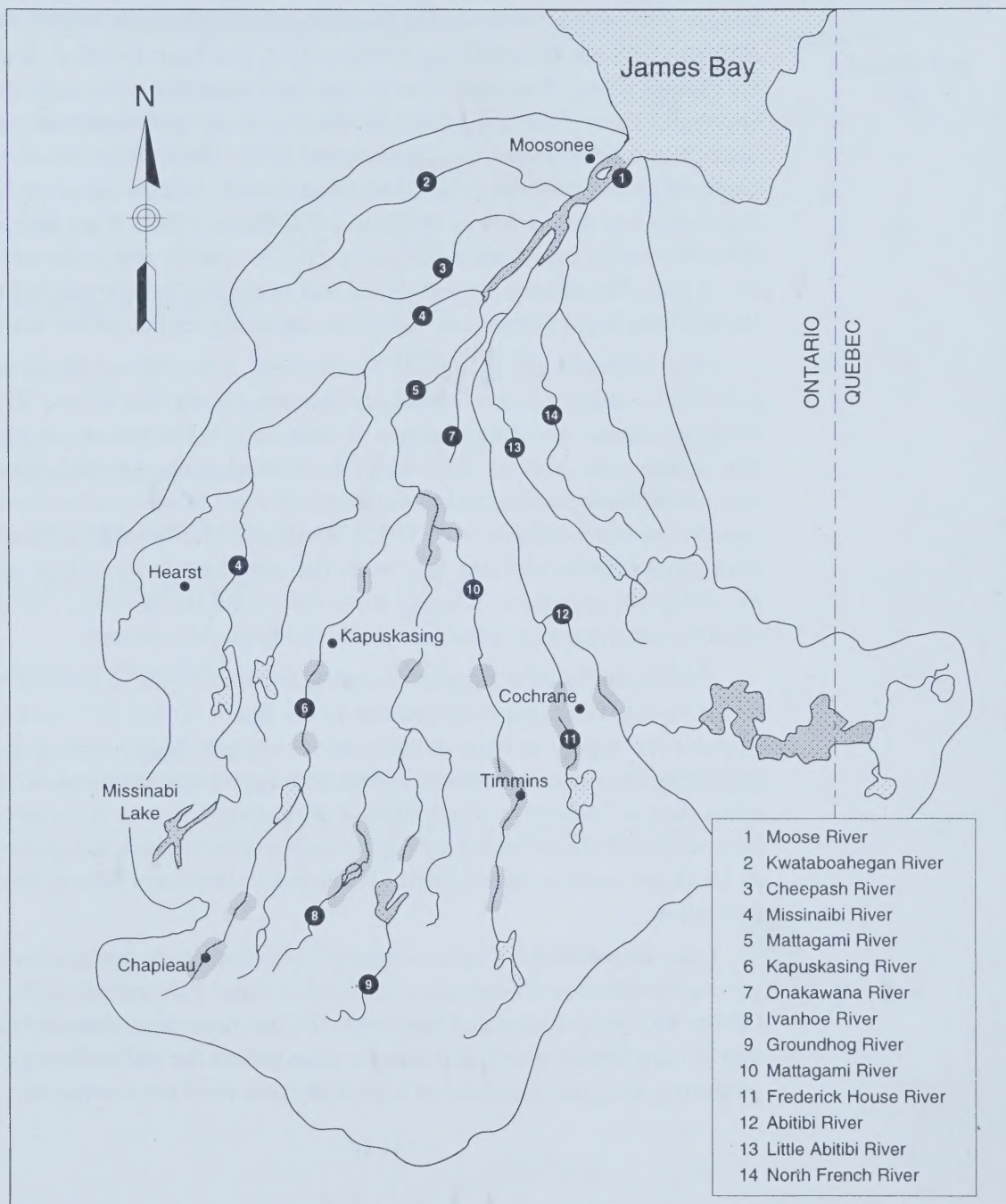


Figure 9: Documented distribution of lake whitefish (*Corregonus clupeaformis*) within the Moose River Basin.

CIMA 1991, NES 1993), and in headpond areas (Sheehan 1989, Lucking 1971). Evidence of lake whitefish spawning activity has been found at several sites on the Abitibi River. Ripe male and female lake whitefish were captured between October 22 and 27 at Long Sault Rapids however, environmental parameters (e.g. water temperature) were not documented (NES 1993). Ripe females were captured in the Iroquois Falls Generating station tailrace between November 3 and 5 at water temperatures of 3.0 to 5.5 C (Beak 1996). Ripe lake whitefish were associated with coarse substrates (e.g. gravel, cobble) and water velocities of 0.2 to 0.3 m/s. The authors hypothesized that spawning habitat suitability in the tailrace was highly dependant upon the operating regime of the dam.

Lake whitefish are thought to be abundant in the Moose River where a subsistence fishery exists. Managers hypothesize that the Moose River stock may be anadromous, spending portions of their lives in the estuary, in James Bay (John Thompson pers. comm.). Although this remains to be proven it should be noted that anadromous coregonid populations do exist in many other rivers along the James Bay coast (Morin *et al.* 1982). Traditional knowledge accumulated by aboriginal peoples utilizing lake whitefish may help to shed light on this question as well as the general ecology of these fish in the Hudson Bay lowlands. No information regarding whitefish yields has been documented.

Although Figure 9 suggests a spotty distribution for this species, they likely occur throughout large river systems in the Basin. Small self-sustaining sub-populations appear to exist in mainstem reservoirs, headponds and in reaches providing lake-like conditions. Individuals captured periodically in more riverine areas may be indicative of population drift along rivers or from lakes. Generally, lake whitefish do not make up a large component of river fish communities except in localized areas as noted above. Whitefish in the lower Moose River may be the exception.

Lake whitefish have been sampled for contaminant analysis but tend to be poor accumulators of mercury compared to other fish species in the Basin (Table 16). Polychlorinated biphenyls (PCBs) have been detected at only one site and at very low levels. Small sample sizes reflect the difficulties associated with obtaining adequate numbers of whitefish from river environments.

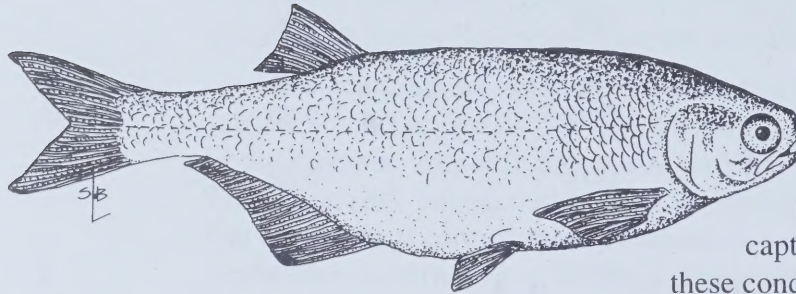
Table 16: Contaminant sampling data for lake whitefish, Moose River Basin.

Site	Year	Mean [Hg] (ppm)	Sample Size (n)
Moose River	1976(1)	0.12	1
	1977	0.16	4
	1978	0.15	15
	1979	0.18	27
Kapuskasing River (Big Beaver Falls)	1992	0.00	1
Abitibi Lake	1971	0.14	5
	1982	0.20	12
Mattagami River (Sturgeon Falls Generating Station)	1975	0.09	1
Minisinakwa Lake (Mattagami River)	1976	0.24	2
Kenogamissi Lake (Mattagami River)	1977(2)	0.23	34
	1981	0.22	30
Horwood Lake (Groundhog River)	1977	0.41	6
(1) Mirex,PCBs below detectable limit.			
(2) Mean PCB concentrations = 0.9 ppm (federal guideline for consumption < 2.0 ppm).			

7.0 GOLDEYE (*Hiodon alosoides*)

Goldeye (*Hiodon alosoides*) distribution is limited to Lake Abitibi and the Abitibi, Frederick House, Moose and Mattagami Rivers (**Figure 10**).

Other than a few additional isolated locations in northeastern Quebec, this represents the species' entire distribution in eastern Canada (Scott and Crossman 1973).



It appears that goldeye are not evenly distributed throughout their range, likely a consequence of habitat preferences. Goldeye prefer turbid, slow flowing sections of river and have been captured in fairly large numbers in

these conditions in the Abitibi (CIMA 1991,

Gibson *et al.* 1984) and Frederick House Rivers (McCrudden 1982, Nowak and MacRitchie 1984). Goldeye have been conspicuously absent in fish catches taken from fast flowing reaches. It has been suggested that the creation of headponds on the Abitibi River will favor goldeye by creating additional habitat (CIMA 1991).

Goldeye spawn in spring/early summer once water temperatures reach 10 to 12 C, in turbid pools and backwater areas (Kennedy and Sprules 1967). No spawning observations have been made within the Moose River Basin, although ripe female goldeye were captured in the Abitibi Canyon as late as July (Gibson *et al.* 1984). Goldeye eggs are semibuoyant, a characteristic unique among North American freshwater fishes (Scott and Crossman 1973) and may drift considerable distances downstream following spawning. Goldeye are thought to overwinter in deep areas in rivers.

It has been hypothesized that juvenile and adult goldeye occupy separate habitats due to reproductive and feeding behaviors (Scott and Crossman 1973). However, a wide variety of year classes, aged 1+ to 7+ were captured together at sampling sites along the Frederick House River in 1982 (McCrudden 1982).

YOY goldeye have been captured in seine nets in the main channel of the Abitibi River in wide, slow flowing reaches and in shallow back eddies (CIMA 1991). Yearling goldeye have been captured in small tributaries of the Frederick House River as far as 2 km. upstream of the main channel. In low flows over mud substrates (OMNR 1981). Yearlings captured in gillnets downstream of rapids on the Frederick House River appeared to be utilizing the same habitat as adults (McCrudden 1982).

Goldeye make up a significant proportion of the fish community, where they occur. MacRitchie (1983) concluded that goldeye make up the

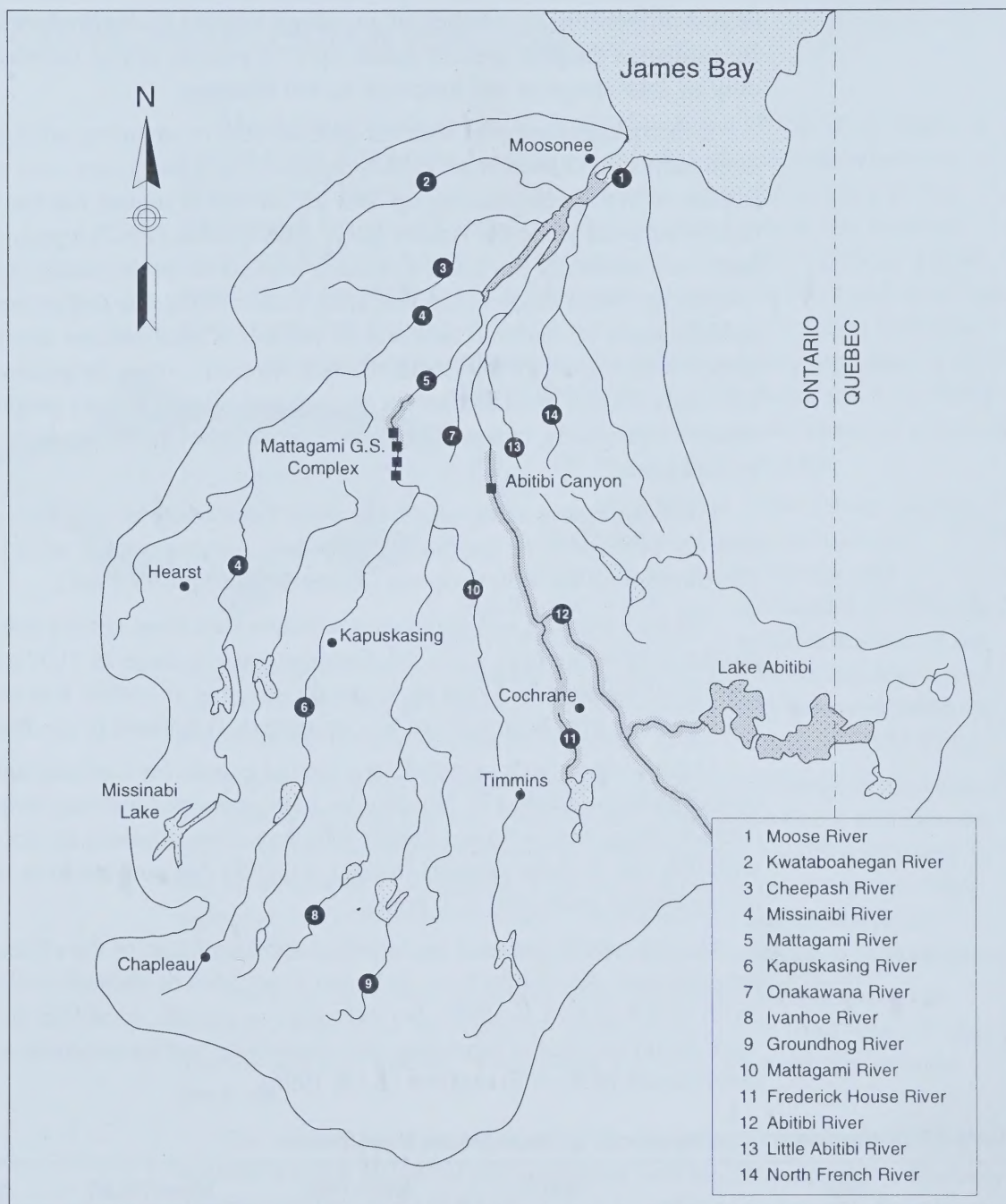


Figure 10: Documented distribution of goldeye (*Hiodon alosoides*) within the Moose River Basin.

largest proportion, by number, of any single species in the Frederick House River. He estimated that this species makes up 17.6 percent of fish biomass, surpassed only by lake sturgeon and longnose sucker biomass.

Investigators have met with variable success in capturing adult goldeye in large numbers. Gibson *et al.* (1984) reported that goldeye are very susceptible to capture with trapnets, making up over 26 percent of trapnet catches by number in headpond areas along the Abitibi River. McCrudden (1982) reported that catch rates vary markedly from reach to reach dependent on the suitability of habitat conditions. In his study of the Frederick House River, the author reported that goldeye made up between zero and 66 percent of total catches along a 40 km stretch which spanned numerous reaches. Mortality rates for goldeye gillnetted in this study ranged from zero to ten percent and seemed to vary proportional to water temperatures, indicating that they are tolerant to netting stress and handling, in cool water.

Food preference information has never been collected for goldeye. However, they are believed to be opportunistic feeders, preying upon a variety of insects and fish throughout the water column (Kennedy and Sprules 1967).

Goldeye meristic and population structure data from netting projects within the Basin have not been analysed. Goldeye grow as large as 1100 g and are periodically caught and kept by anglers (Gibson *et al.* 1984). It is unclear if goldeye have ever been utilized by commercial fishermen in the Basin.

Goldeye have been sampled, to a limited extent, for contaminant concentrations (**Table 17**). No samples have contained mercury concentrations deemed dangerous to human health. Mercury concentrations do not correlate well with fish size in these samples (mean $r = 0.295$). No samples have exceeded PCB concentration guidelines (2.0 ppm).

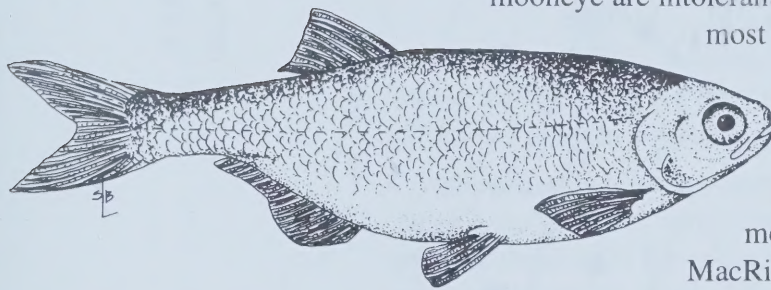
Goldeye are being used as a sentinel species as part of the effects monitoring program near the Abitibi Price Pulp and Paper Mill in Iroquois Falls on the Abitibi River (BAR and NLK 1995). No difference in growth, condition and gonadal size were found in goldeye inhabiting the control site and the exposure zoon located downstream of the mill outflow (BAR 1996).

Table 17: Contaminant sampling data for goldeye, Moose River Basin.

Site	Year	Mean [Hg] (ppm)	Mean [PCB] (ppm)	Sample Size (n)
Abitibi Lake	1990	0.38	00	19
	1974	0.26	—	17
	1970	0.13	—	6
Abitibi River (Abitibi Canyon)	1977	0.47	54	15
	1970	0.33	—	10
Frederick House Lake	1990	0.15	—	12
	1977	0.46	18	14

8.0 MOONEYE (*Hiodon tergisus*)

Mooneye (*Hiodon tergisus*) distribution in the Moose River Basin is limited to the Abitibi and Frederick House Rivers and their respective headwaters (**Figure 11**). Very little is known about the biology of this species as it has never been of commercial importance in the Basin or elsewhere in North America. Scott and Crossman (1973) provide a brief summary of mooneye ecology. Mooneye inhabit both lakes and rivers but prefer clear, fast flowing fluvial systems. Scott and Crossman state that mooneye are intolerant to silty habitat yet they are found in the



most turbid rivers of the Basin and have failed to colonize the clearer waters of rivers on the Basin's western edge.

Very little is known about habitat preferences of adult and juvenile mooneye in the Basin. Nowak and MacRitchie (1984) and McCrudden (1982) note that mooneye were found only in specific reaches of the Frederick House River characterized as having fast flows and less turbid waters. Nowak and MacRitchie (1984) estimated that mooneye made up less than one percent of total fish biomass in the Frederick House River.

Investigators have failed to capture significant numbers of mooneye in any gear other than gillnets. Their habitat preferences likely preclude the use of heavy stationary gear such as trapnets which are difficult to use in fast flowing water. Gillnetting, even short duration, results in very high mooneye mortalities. McCrudden (1982) reported that mooneye are intolerant to capture and handling stress, regardless of water temperatures.

Mooneye are spring spawners. Ripe individuals were captured at Neelands Rapids on the Frederick House River, in the third week of May (Nowak and MacRitchie 1984). These fish were primarily six to eight years old.

The oldest mooneyes captured in the Basin were 11+ years, having attained a mean weight of 425 g (Nowak and MacRitchie 1984). The only information regarding diet is from EAG (1980) who report that mooneye in the lower Abitibi River fed on mayflies, stoneflies and amphipods.

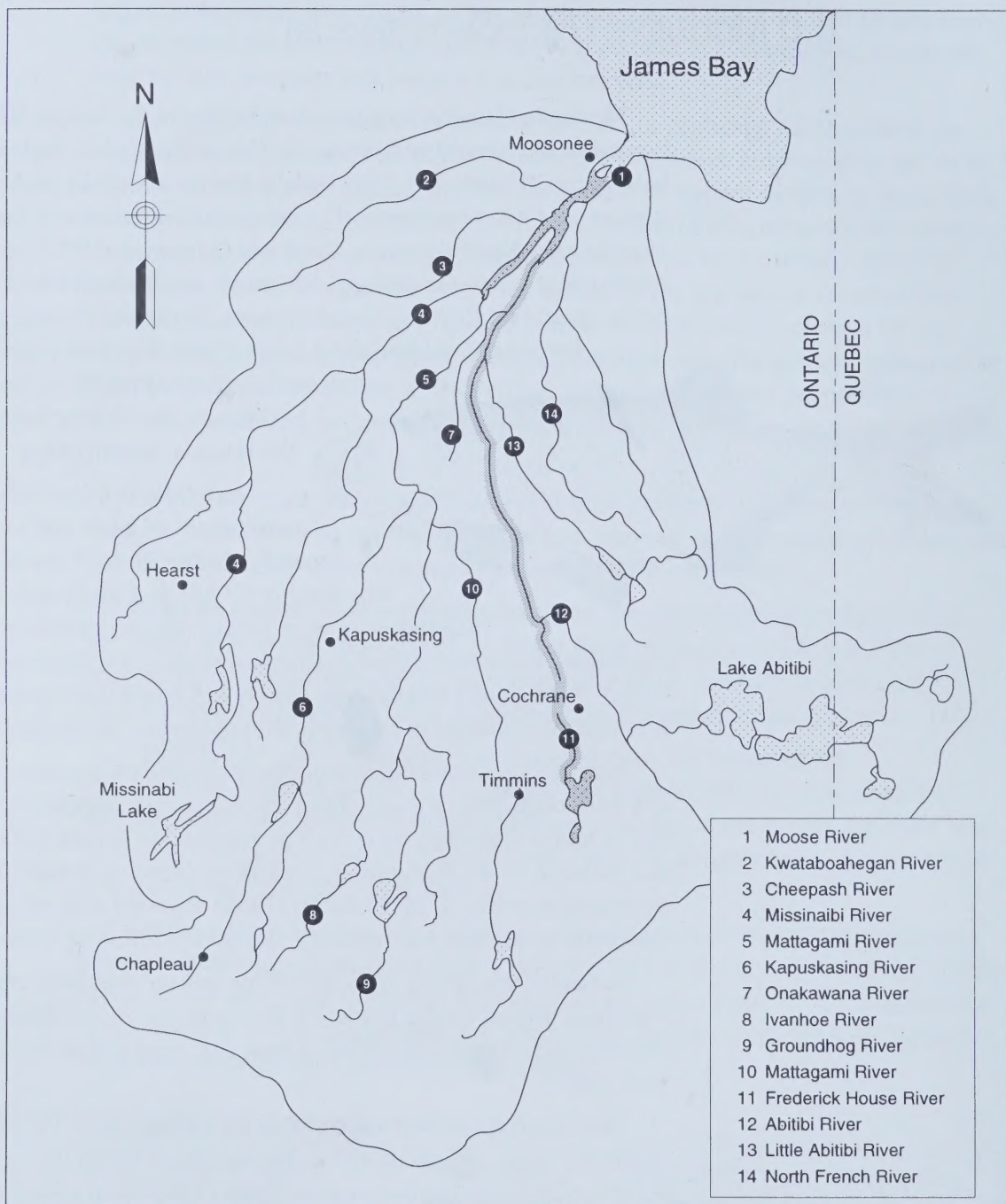
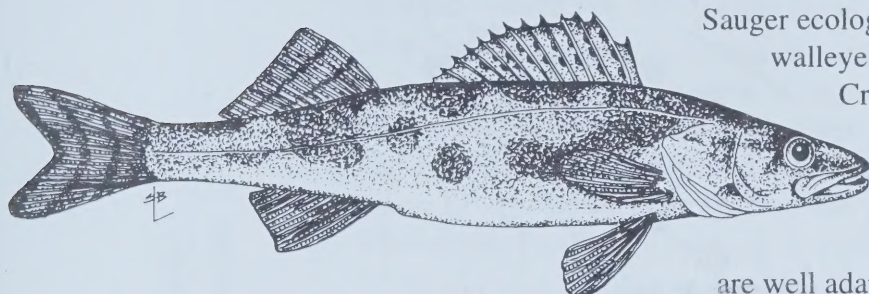


Figure 11: Documented distribution of mooneye (*Hiodon tergisus*) within the Moose River Basin.

9.0 SAUGER (*STIZOSTEDION CANADENSES*)

Sauger (*Stizostedion canadenses*) distribution is limited to the Clay Belt portions of the Abitibi and Frederick House Rivers (**Figure 12**).



Sauger ecology is believed to be similar to walleye. According to Scott and

Crossman (1973), sauger spawn on gravel or boulder substrates, will utilize the same sites as walleye, and can hybridize with walleye. They are sight predators,

are well adapted to hunting in turbid waters and feed primarily upon fish and invertebrates.

Sauger will compete for food resources with northern pike, walleye and goldeye, all of which inhabit the Abitibi and Frederick House Rivers.

Investigators have been successful in capturing sauger in both trapnets and gillnets. Sauger made up 6.9 percent of the total gillnet catch on the Abitibi River during the summer of 1989 (CIMA 1991) but were only captured in long, flat sections of river, below rapids and fast flowing narrows.

In the Frederick House River, sauger made up 3.6 and 7.6 percent of spring trapnet catches in 1981 and 1983, respectively (Nowak and MacRitchie 1984). The authors estimated that sauger represented between 1.3 and 2.5 percent of large fish biomass in that river, approximately one half that of walleye. The authors reported that most sauger were captured in sections characterized by long, slow flowing runs.

McCrudden (1982) reported that sauger made up one percent of the catch during short duration summer and autumn gillnetting on the Frederick House River. Netting mortalities varied directly with water temperatures.

In all of the projects noted above, regardless of season, sauger were captured in the same locations as walleye, indicating that these species utilize the same habitat. Stomach content analysis, which may have shed some light on diet overlap between walleye and sauger, has never been carried out.

Sauger in spawning condition were noted below the rapids at Flood's Landing between May 7 and 16 and at Neelands Rapids, May 12 to 20 (Nowak and MacRitchie 1984) on the Frederick House River. Water temperatures varied between 3.0 and 6.0 C. The youngest ripe males were 4+ years while females were as young as 5+ years in both instances. Ripe sauger were also captured on shoals in the Island Falls headpond area on the Abitibi River in late May 1984 (OMNR 1984).

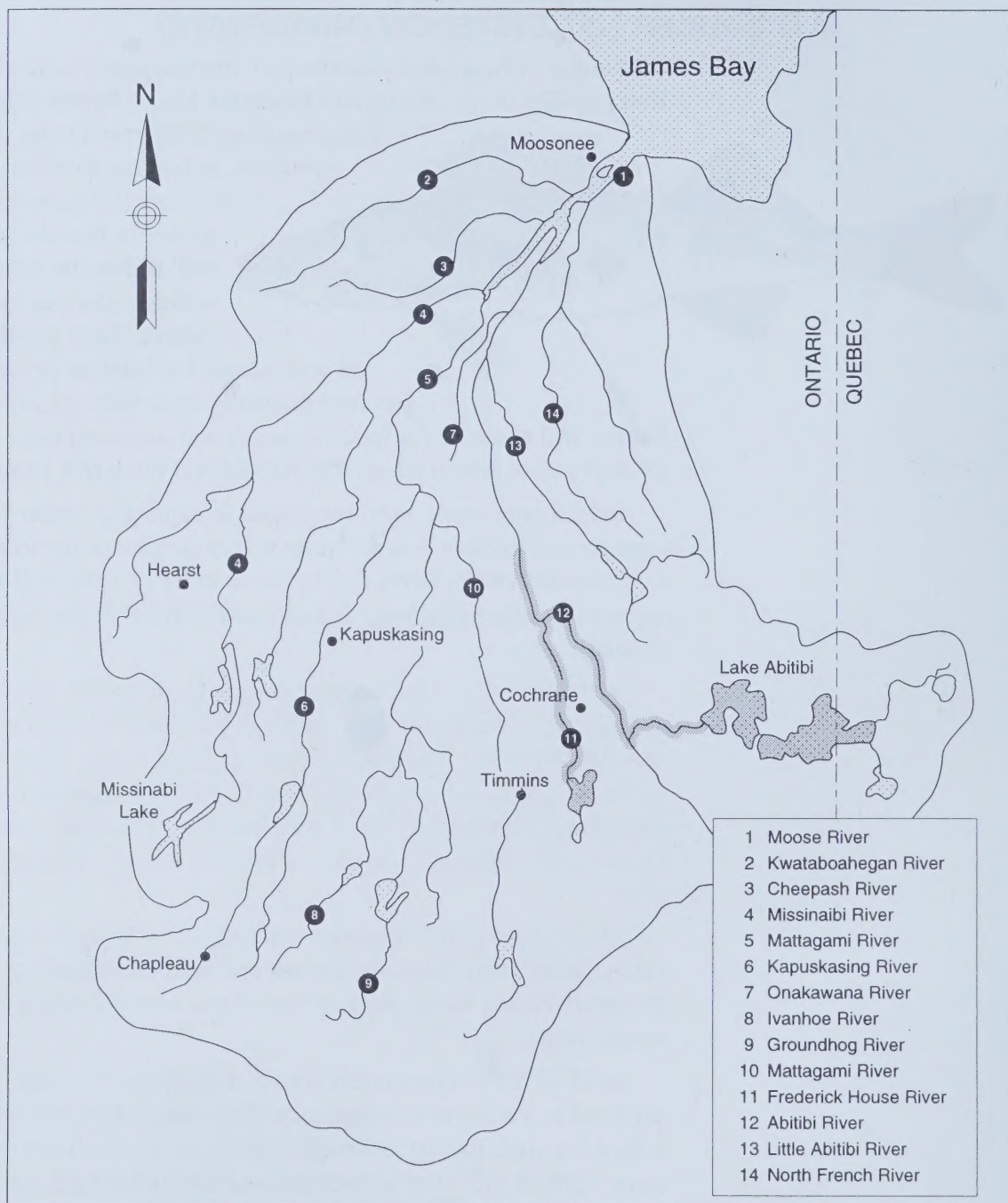


Figure 12: Documented distribution of sauger (*Stizostedion canadenses*) within the Moose River Basin.

YOY sauger have been captured in seine nets in main river channels, in slow flowing water. In most cases, substrates were rubble or clay, and instream vegetation and cover was sparse (OMNR 1983b). There are no recorded instances of YOY sauger being captured with YOY walleye.

No length-at-age correlations or condition indices have been computed for sauger in the Basin, however, it appears that they grow at a slower rate than walleye captured in the same waters (Nowak and MacRitchie 1984). The majority of sauger captured during spring trapnetting on the Frederick House River were 4+ to 8+ years of age. The oldest individual captured was estimated to be 13+ years, 40.5 cm and 850 g.

Sauger are harvested periodically by anglers across their range however, most of these are likely taken incidentally, mistaken for walleye.

Sauger have been examined for contaminant burdens, however, only in headwater lakes (**Table 18**). Mean mercury concentrations in sauger from Lake Abitibi are higher than those from Nighthawk and Frederick House Lakes. Because of the slow rate of growth exhibited by this species, one might expect to find high contaminant concentrations in small fish relative to faster growing percids such as walleye. Sauger from Lake Abitibi, longer than 35 cm, are not recommended for human consumption (MOEE 1984). Correlations between sauger length and mercury body burden are generally weaker than in walleye.

Table 18: Contaminant sampling data for sauger, Moose River Basin.

Site	Year	Mean [Hg] (ppm)	Corr. (r)	Sample Size (n)
Abitibi Lake	1971	0.91	0.756	40
	1973	0.94		16
	1974	0.81		24
	1980	0.90		15
	1984	0.75		19
	1990	0.83		4
Frederick House Lake	1990	0.28	0.676	20
Night Hawk Lake	1972	0.60	0.750	11

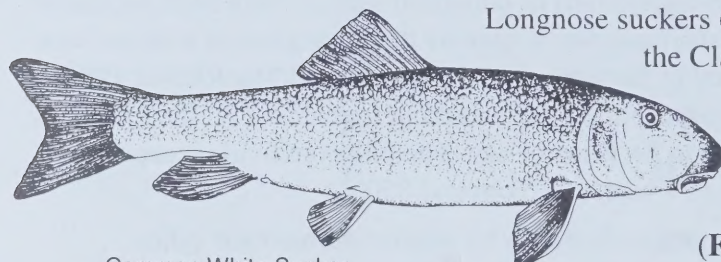
10.0 CATOSTOMIDS

Three species of catostomids inhabit rivers in the Basin. Common white suckers (*Catostomus commersoni*) are found throughout the Basin.

Longnose suckers (*Catostomus catostomus*) are found throughout the Clay Belt but are absent in the southern Shield

portions of the Basin (**Figure 13**). Shorthead redhorse sucker (*Moxostoma macrolepidotum*) distribution is limited to the Abitibi River watershed and lowland portions of the Basin

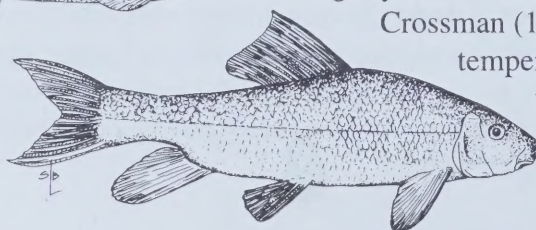
(**Figure 14**).



Common White Sucker



Longnose Sucker



Shorthead Redhorse Sucker

All three catostomids are spring spawners, utilizing gravel and boulder substrates, in shallow, fast flowing areas. They have similar spawning habitat requirements and may utilize the same sites as walleye, slightly later in the spring. According to Scott and

Crossman (1973), longnose suckers spawn at water temperatures around five degrees celcius

while white sucker spawning activity

commences at slightly higher

temperatures. Common white and

longnose suckers are daylight

spawners, while shorthead redhorse

suckers spawn at night. Data

collected at Neelands Rapids, on the

Frederick House River, suggests

that the spawning period for all three species may overlap (**Table 19**).

Table 19: Spawning observations for catostomids in various rivers of the Moose River Basin.

Species	Date	Location	Source
Longnose sucker	May 4 to 18	Neelands River Frederick House River	Nowak and MacRitchie (1984)
Common white sucker	May 6 to 21	"	"
Shorthead redhorse sucker	May 19 to 26	"	"
Common white sucker	May 14 to 24	Island Falls, Mattagami River	MacRitchie (1984b)
Common white sucker	May 9 to 17	Carmichael Falls	NEA (1988)

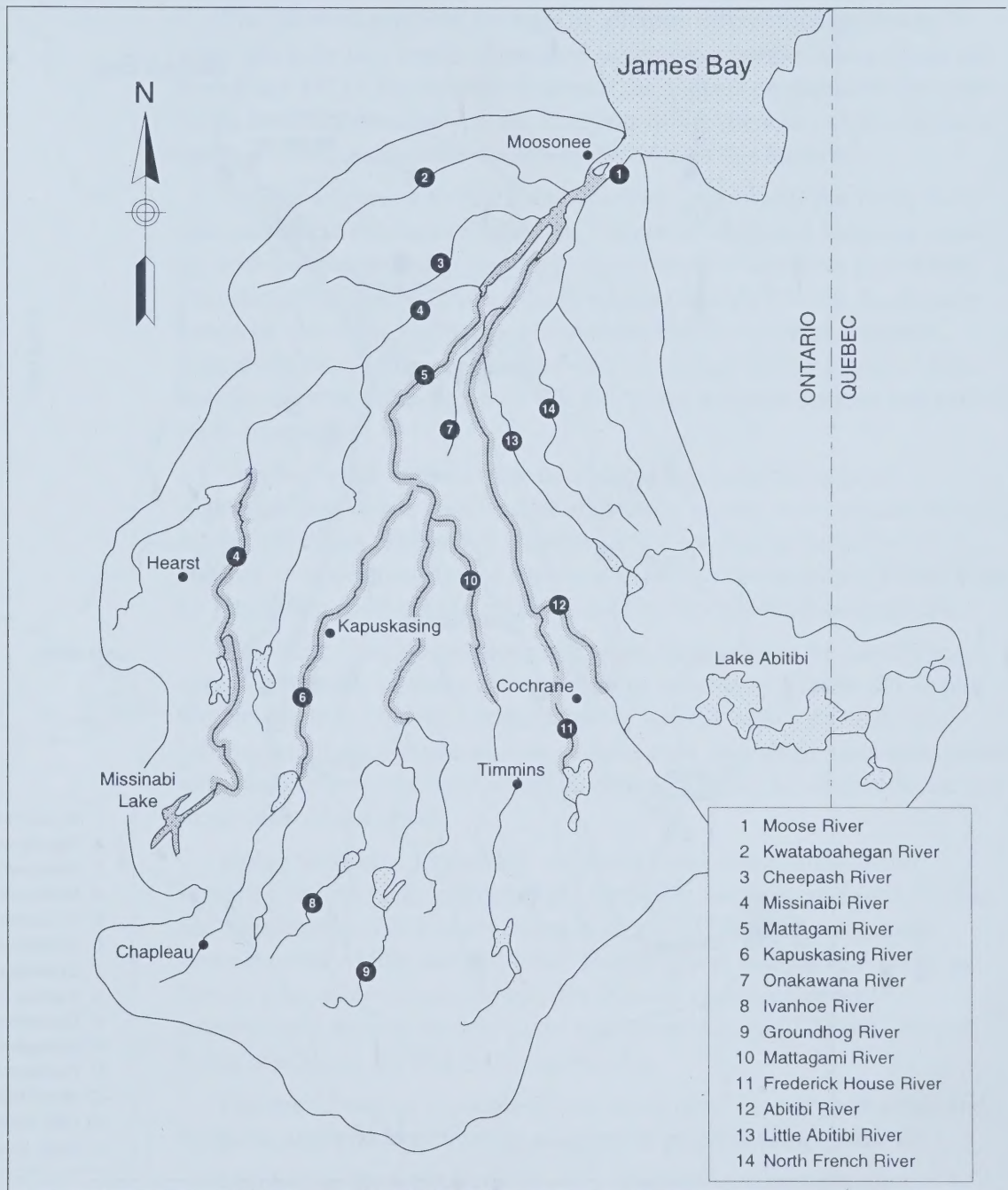


Figure 13: Documented distribution of longnose suckers (*Catostomus catostomus*) within the Moose River Basin.

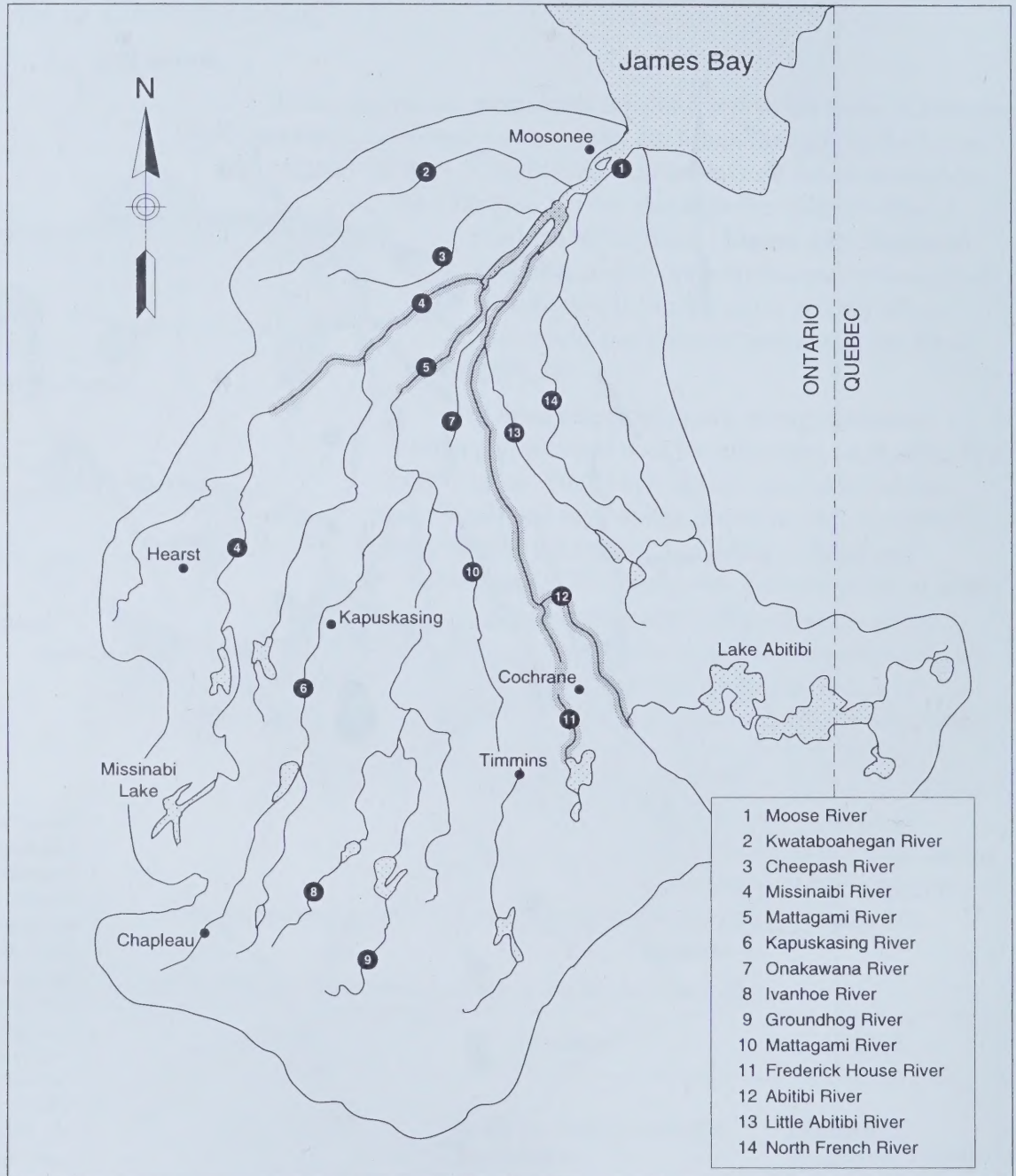


Figure 14: Documented distribution of shorthead redhorse sucker (*Moxostoma macrolepidotum*) within the Moose River Basin.

The incubation period for eggs of all three catostomid species is approximately two weeks, dependent upon water temperatures (Scott and Crossman 1973). Fry initially feed near the surface on plankton and other small invertebrates. Early in the first year of life there is a shift to bottom feeding which persists for the remainder of their life histories.

Habitat utilization by YOY and yearling catostomids has rarely been documented in the Basin (**Table 20**). Common white and longnose sucker fry have been captured in large schools on shallow sand and gravel bars (Sheehan 1989) and in shallow back eddies (OMNR 1983b). In all cases longnose and white suckers were captured together in large numbers, suggesting that habitat preferences may be similar for the young of both species. Habitat utilization by YOY shorthead redhorse suckers has not been documented.

Yearling white suckers have been captured along the edge of mainstem flats and in small inflowing creeks, usually over organic or coarse substrates (**Table 20**). Capture sites were characterized by an absence of vegetation, sparse instream cover and low currents. Habitat use by longnose and shorthead redhorse suckers has not been documented.

Adult and juvenile longnose and white suckers have frequently been captured together in many different habitat conditions (**Table 20**). White suckers tended to utilize a wider range of current velocities, than did longnose suckers. Adult longnose suckers have frequently been associated with low currents and deep water. Habitat utilization by adult redhorse has never been documented.

Aging structures were rarely collected from catostomids during sampling projects and length/weight data have not been analysed. Nowak and MacRitchie (1984) and Gibson *et al.* (1985) noted that longnose suckers in the Abitibi and Frederick House Rivers had poorer condition factors than other catostomid species. Nowak and MacRitchie hypothesized that the Abitibi River watershed may provide sub-optimal living conditions for this particular species.

Figures 15 and 16 illustrate gillnet catch rates for common white and longnose suckers, from various assessment projects (**Appendix VI**).

Catch rates for white suckers were relatively consistent across sampling periods in headponds, while catches in riverine habitat increased in September and October. Catch rates for common white suckers in riverine habitat were two to six times higher than for longnose suckers throughout the year. CPUE for longnose suckers were highest in mainstem headponds.

Table 20: Catostomid river habitat utilization (common white and longnose suckers), Moose River Basin.

Date	Location Description	Source
I. Adults/Juveniles (common white (cws) and/or longnose (lns) suckers as indicated)		
May	• (cws/lms) main channel troughs, shallow water (2 - 4 m), sand/ bedrock substrates	NEA (1992)
June	• (cws/lms) channel troughs, near mouths of creeks, clay/bedrock substrates, shallow water (2 - 6 m)	NEA (1993)
	• (lms) pools (6 - 8 m), sand/bedrock substrates	..
	• (cws) channel troughs/shallows, shallow water (2 - 4 m), moderate currents (40 to 80 m/sec)	Seyler (1996)
	• (lms) pools (6 - 8 m deep), low currents	..
July	• (cws/lms) main channel troughs, moderate flows	CIMA (1991)
	• (lms) backeddies, shallow water, mouths of inflowing creeks, low currents	..
	• (lms) pools, low currents	..
October	• (cws) within small inflowing creeks, low currents, extensive vegetation	EAG (1979)
II. Yearlings (common white suckers only)		
June	• edge of main channel trough, mud/rubble substrates, low currents (10 cm/sec), sparse instream cover	OMNR (1983b)
July	• small inflowing creeks, sand/gravel substrates, no instream vegetation, low current	Sheehan (1989)
August	• edge of main channel trough, mud/gravel substrates, low currents, sparse instream cover	OMNR (1983b)
III. Young-of-the-year (common white and longnose suckers)		
June	• shallow back eddies below rapids, mud/substrates, no instream cover	OMNR (1983b)
June	• sand/gravel bars, low current	Sheehan (1989)
June/July	• sand/gravel bars, near mouths of inflowing creeks, no instream vegetation, low currents	..

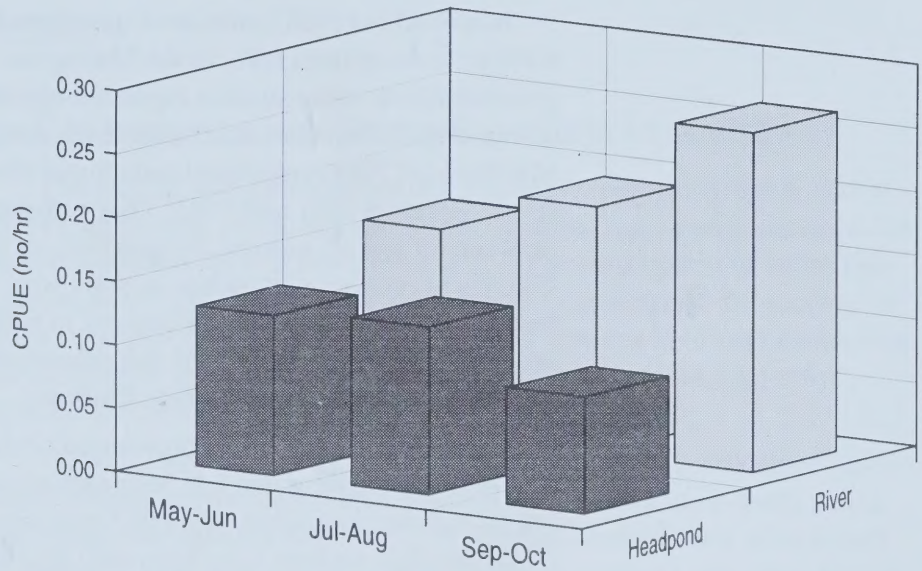


Figure 15: Seasonal catch rates (CPUE) for common white suckers (*Catostomus commersoni*) in headpond and riverine habitats, using 25 to 27 mm gillnets (from Appendix VI).

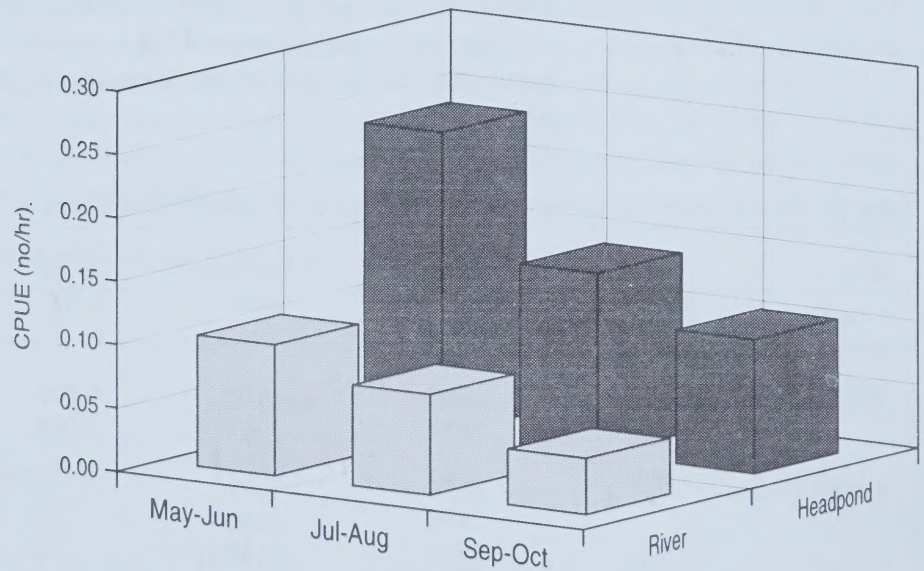


Figure 16: Seasonal catch rates (CPUE) for longnose suckers (*Catostomus catostomus*) in headpond and riverine habitats using 25 to 127 mm gillnets (from Appendix VI).

MacRitchie (1984) calculated catostomid population size, relative to walleye and northern pike, in the Mattagami and Kamiskotia Rivers. He concluded that white suckers represent approximately 62 percent of the fish community. Longnose suckers made up sixteen percent. Nowak and MacRitchie (1984) calculated catostomid abundance on the Frederick House River in 1981 and 1983. They estimated that catostomids made up between 45 and 63 percent, by numbers, of the large fish community. Catches of longnose and white suckers were extremely variable between years resulting in two fold differences in population estimates for these species. The authors estimated that catostomids made up between 30 and 50 percent of the fish community biomass.

Catostomids have rarely been sampled for contaminant concentrations. The limited sampling that has been carried out suggests that white suckers are poor bioaccumulators of methyl mercury (**Table 21**). Concentrations of PCBs in white suckers have been well below Provincial guidelines.

It has been shown that changes in common white sucker population dynamics, physiology, reproductive potential and metabolic function are related to exposure to low level contamination (Munkittrick and Dixon 1989a, Munkittrick *et al.* 1991). Common white suckers are being utilized as sentinel species as part of effects monitoring programs near pulp and paper mills on the Abitibi and Kapuskasing Rivers (BAR 1993, BAR and NLK 1995).

Table 21: Contaminant sampling data for white suckers, Moose River Basin.

Site	Year	Mean [Hg] (ppm)	Corr. (r)	Mean [PCB] (ppb)	Sample Size (n)
Mattagami River	1990	0.16	0.827	48	14
	1990	0.21	0.508	14	18
Moose River	1978	0.61	—	—	15
	1979	0.46	—	—	22
	1984	0.32	—	—	5

11.0 DISCUSSION

11.1 FISH COMMUNITIES AND RIVER FISHERIES MANAGEMENT

The lack of a comprehensive fish species inventory spanning entire river continuums, watersheds and physiographic region boundaries in the Basin precludes the classification and accurate description of entire fish communities. This impairs our ability to fully understand the ecology of river fish communities and limits managers' options in terms of selecting target species upon which to base impact assessment and long-term effects monitoring programs.

Table 22 proposes an ecological fish community classification based upon several, easily discernable physical characteristics of rivers across the Basin, discussed in Section 1.1. River fish communities within each community type appear to be similar, based on existing data. This broad classification represents a first step towards explaining similarities and differences between fish communities in sections of rivers traversing different physiographic regions. There are, undoubtedly, more accurate physical determinants of river fish communities within discrete sections of rivers. Additional information on the physical nature of these systems on finer scales will be required in order to refine this hypothesis. Managers should be wary of comparing fisheries data between communities types as interspecific relationships and habitat partitioning within each is likely distinct.

Table 22: Large river fish community matrix, Moose River Basin.

Community Type	Physical Characteristics			Fish Community Diversity (Source: Table 1)
	Gradient	Turbidity	Mean Depth	
Upper Missinaibi River Fish Community e.g. upper Missinaibi River	High	Low	Low	Mod.
Shield River Communities e.g. Chapleau River, upper Kapuskasing River, upper Mattagami River, Ivanhoe River	High	Low	High	Low
Clay Belt River Communities e.g. Groundhog River, middle Mattagami River	Mod.	High	Mod.	Mod.
Abitibi River Watershed Communities e.g. upper Abitibi River, Frederick House River	Mod.	High	Mod.	High
Lowland River Communities e.g. Moose River, lower Abitibi/Mattagami/Missinaibi Rivers	Low	High	Low	High

Kitchell *et al.* (1977) defined percid habitat on the basis of environmental conditions in large temperate Rivers. The authors suggest that similar environmental criteria can be applied to describe habitat and explain relative abundance of other fish species. Figure 17 is a graphic representation of the information contained in Table 22, explaining how the relative abundance of selected fish species varies between river community types. The shapes of these curves have been derived from information presented in previous sections, including habitat utilization data, species habitat requirements, angler yields, CPUE from assessment projects, biomass and population estimates, and our limited knowledge, concerning interspecific relationships and niche overlap in these rivers. This model attempts to explain the relative abundance of fish species over broad spatial scales. There will be local situations such as headponds or degraded sections of rivers where such relationships will not hold true. Although we

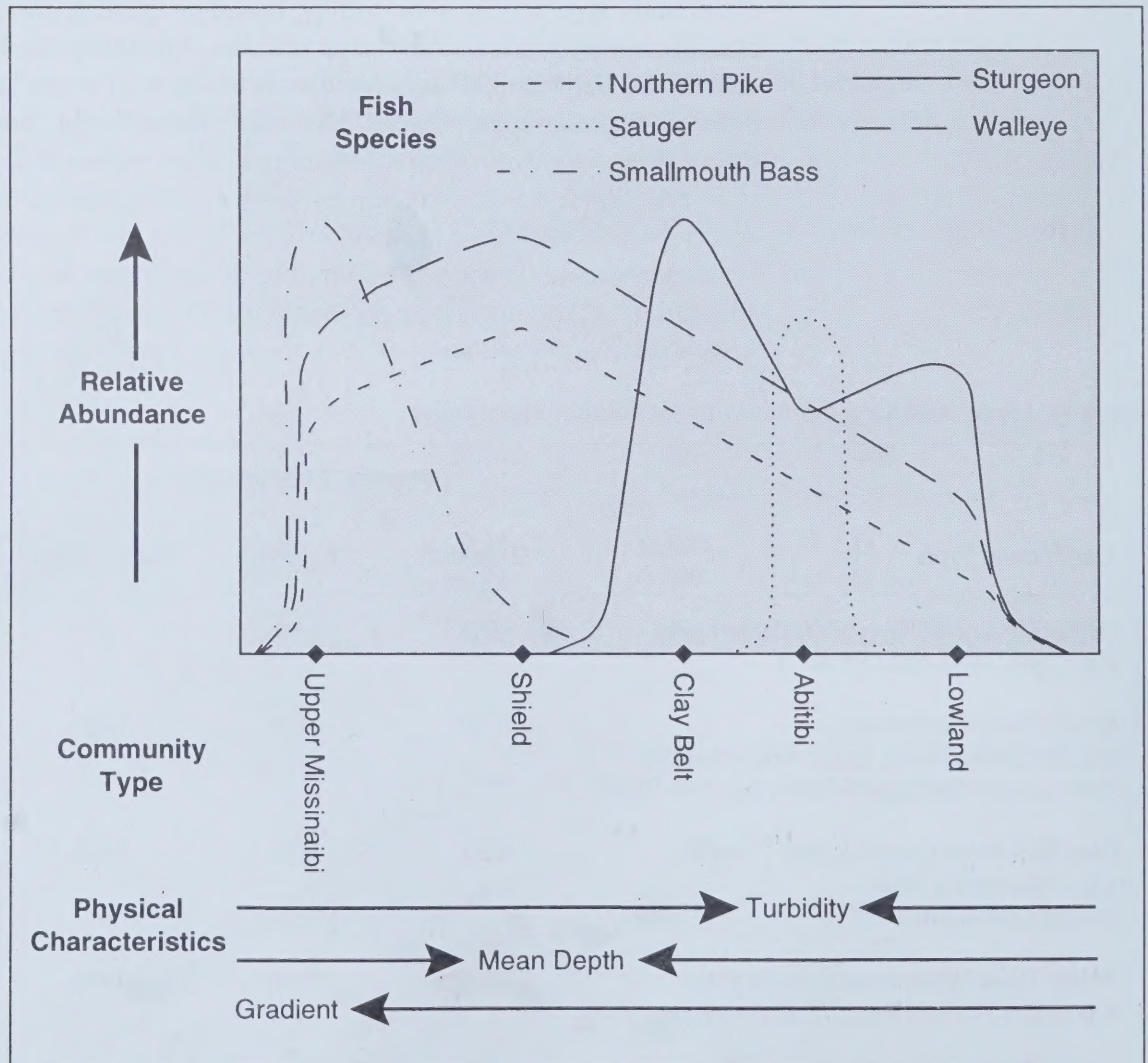


Figure 17: Relative abundance of selected river dwelling fish species in relation to fish community types (See: Table 22).

lack data necessary to quantify species abundance, this model will help managers to understand how yields and available instream resources may be partitioned within each particular river fish community.

Very little is known about rivers along the western edge of the Basin. Physical conditions and the fish community of the upper Missinaibi River are unique, making it a poor reference for large river fish communities in more developed portions of the Basin. Smallmouth bass and fallfish are abundant, indicative of high water clarity. Brook trout inhabit many of the inflowing tributaries of the Missinaibi River watershed and are occasional residents in the mainstem river. The Upper Missinaibi River remains in a relatively pristine state, protected as part of a Provincial park. This portion of the Basin affords opportunities for pure research into community interactions and aquatic ecology within a natural environment.

Large rivers traversing the southern third of the Basin the shield river communities originate near the height of land. Walleye and northern pike are generally more abundant in this area, compared to the Clay Belt and Lowland portions of the Basin. Thus, these rivers have the highest potential to provide sport fishing opportunities. Headwater storage reservoirs are the major form of instream development along these rivers. Habitat management initiatives should focus on the maintenance of suitable instream flows and water levels during and immediately following spawning periods. In situations where managers are concerned with early season angling yields associated with congregations of spawning walleye and northern pike, the use of temporary sanctuaries is recommended. Information needs for these communities include the locations of spawning sites and documentation of spawning activity (e.g. water temperatures, dates) for various fish species.

Sections of rivers located in the Clay Belt generally provide lower quality habitat for walleye and northern pike. The exceptions to this may be where headpond construction has resulted in the creation of lake-like habitat. Lake sturgeon are abundant in these systems. As the dominant benthic feeder, sturgeon may act as a biological control on other species whose diets depend upon benthic organisms. The vast majority of river fisheries investigations have focused on these communities but the objectives of most studies have been related to quantifying abundance and biomass. The majority of instream development has occurred within Clay Belt rivers and our knowledge of fish-habitat relationships is poor. Maintaining suitable habitat must be the focus of managers concerned with Clay Belt river fish communities. There is a need to define fish habitat use across the Clay Belt. The development of seasonal habitat utilization relationships at both macrohabitat (e.g. channel morphology) and microhabitat scales (e.g. flow/depth preferences) should be an information priority to managers. This information is required for a variety of species and life history stages (**See Section 11.4**).

It can be argued that rivers along the eastern edge of the Basin are the only true 'Clay Belt rivers' as their origins lay along the Northern Clay Belt. Although there are many similarities between physical conditions in rivers within the Abitibi River watershed and sections of rivers located elsewhere across the Clay Belt, there are differences in their respective fish communities. Sauger, mooneye and goldeye populations make up significant portions of fish communities in the Abitibi and Frederick House Rivers. Resource partitioning and fish habitat relationships may be much more complex within this watershed than elsewhere in the Clay Belt. Many sections of the upper Abitibi River have been converted to headpond habitat due to extensive development. The present status of lake sturgeon in the Abitibi River is unknown. The Frederick House River may act as a biological reservoir for the Abitibi River, as it provides relatively unfragmented fish habitat. Management information needs for the Abitibi River are similar to rivers elsewhere on the Clay Belt, however, habitat utilization relationships should include reservoir attributes in addition to riverine variables.

The lower reaches of the Abitibi, Mattagami and Missinaibi Rivers and the Moose River lie within the Hudson Bay lowlands. These rivers are generally wide, shallow and flat. Although hydroelectric development potential has been identified in the lowlands (Ontario Hydro 1978), it is unlikely to proceed in the immediate future. The biggest impact of existing development on lowland river fisheries is related to peaking flows in reaches below Otter Rapids Generating station, and Kipling Generating station on the Abitibi and Mattagami Rivers, respectively. Studies conducted at Onakawana, located approximately 50 km downstream of the Otter Rapids, noted diurnal water level fluctuations of more than one meter during summer months (MOEE 1972). The investigators estimated that one third of the river channel was dewatered during low flows. Carson *et al.* (1991) reported that current peaking operations on the Mattagami River result in a 34 percent reduction in available fish habitat for more than 20 km downstream of Kipling Generating station. Impacts of these fluctuations on food availability, reproductive success and habitat availability for many fish species have never been documented. Future assessment studies should address these gaps. Fisheries in the lowland portions of the Basin have a long history of utilization by First Nation communities at Moosonee and Moose Factory. Traditional knowledge may represent an important source of fish habitat utilization information. The lower Missinaibi River, represents an excellent study area for the development of habitat suitability relationships for key indicator fish species in the lowlands. These relationships should be defined prior to modifying existing flow regimes at peaking facilities south of the lowlands. Fish habitat utilization relationships in Clay Belt and in lowland portions of

the Basin should not be assumed to be identical. Very different physical conditions exist in river channels in these physiographic areas. Some species may exhibit specific behavioral adaptations related to habitat availability in the lowlands.

River fish communities have never been intensively managed in northeastern Ontario. Traditionally, yields are controlled through the use of closed seasons, sanctuaries and possession limits, which seems practical considering the lengths and remoteness of these systems. Brousseau and Goodchild (1989) report that angling pressure is generally light in comparison to lentic systems. Petts *et al.* (1989) provide a good synopsis of river fish population management around the world. The authors conclude that in order to sustain river fish populations and biological communities, emphasis should be placed on managing flow, water quality, sediment transport and their impacts on habitat.

11.2 SAMPLING, ASSESSMENT AND LONG TERM MONITORING

Fish are useful organisms for measuring environmental change. They are sensitive to a wide array of stresses. Fish depend upon many different components of aquatic ecosystems (e.g. habitat, aquatic invertebrates) in order to grow, survive and reproduce, and will integrate the effects of stresses on these components.

Rivers represent highly variable aquatic systems. Physical and chemical conditions within river ecosystems can change abruptly on an annual, seasonal or daily basis in response to environmental changes. Physical changes to fish habitat (e.g. depth, substrate, turbidity and flow) affects fish presence and abundance. This variability means that in order to obtain a representative sample of any river fish community, several gears used in different places at different times of the year are required (Casselman *et al.* 1990). Measuring absolute species abundance is an unrealistic goal due to the open nature of river ecosystems and obtaining estimates of relative species abundance requires very intensive sampling. The variability associated with abundance estimates will undoubtedly be high unless results are explained in light of existing environmental/habitat conditions.

Intensive assessment of several species or entire fish communities in an attempt to obtain a general picture of ecosystem health is unlikely to be useful in measuring statistically significant effects or changes in fish populations (Casselman *et al.* 1985). Long term monitoring to detect such changes is an extremely expensive proposition. For these reasons, it is recommended that river managers refrain from conducting projects designed to assess entire fish communities or measure absolute species abundance.

In order to quantify effects, managers should target single species or single representatives of guilds, groups of species that use similar resources. Indicator fish species should be abundant and sensitive to environmental changes. Sampling designs should target species of concern at sensitive life stages. Species behavior and the size selectivity of gears being utilized must be understood in order to obtain appropriate numbers of target species in a cost effective manner. Environmental parameters such as depth and flow should be measured at sampling sites in order to understand habitat related variability in data. Research is required to determine key indicator species, develop fish habitat utilization models and identify easily measurable behavioral and physiological indices of change in indicator species relative to specific forms of development.

Munkittrick (1992) and Munkittrick and Dixon (1989b) provide a framework for selecting key species for long term monitoring of fish population health. According to the authors, optimal indicator species have a fast growth rate, high fecundity, intermediate life spans, mature early and play an important role in the aquatic food chain. Fish species exhibiting these characteristics respond to change quickly. Munkittrick is currently examining indices of growth, reproductive potential and condition in trout perch and white suckers, across the Basin in order to develop a standard methodology for assessing cumulative effects (Munkittrick *et al.* 1995).

White sucker, walleye and goldeye are the focus of long term environmental effluent monitoring programs near pulp and paper mills in the Basin in accordance with effects monitoring guidelines (Environment Canada 1992). Growth, condition, gonadal size and liver size will be measured in order to detect differences between exposure and control sites.

11.3 CONTAMINANTS

Organochlorine compounds, PCBs and pesticides, have never been identified in fish tissue in the Basin at levels exceeding human consumption guidelines recommended by the Ontario Ministry of Environment and Energy. High concentrations of mercury, on the other hand, have been reported throughout the Basin. Walleye and northern pike are the most efficient bioaccumulators of methylmercury and are also the two fish species most sought by anglers. Mercury 'hotspots' identified to date include mainstem and headwater reservoirs on the Mattagami River, the Kapuskasing River (both up and downstream of the town of Kapuskasing) and the Abitibi River watershed, including some natural lakes.

Headon and Pope (1990) reviewed contaminant data collected between 1975 and 1986 in large rivers and reservoirs of the Basin. The authors

reported that contamination levels in walleye in the Moose River Basin were higher than in many other river systems across the Province of Ontario

Typically, fish mercury concentrations rise for several years following impoundment and then decline towards preimpoundment levels (Johnston *et al.* 1991). In northern reservoirs this decline can take decades due to the slow rate of organic matter decomposition (Bodaly *et al.* 1988, Ramsey 1990). Reservoir construction practices in the Basin in the past involved extensive flooding of highly organic soils and vegetation hence high mercury levels persist. The contribution of natural mercury sources, agriculture, mining and municipal centers to existing problems is unknown.

Sport fish contaminant data collection has been infrequent and random. Few control waterbodies have been sampled. Fish in many mainstem and headwater reservoirs have been sampled only once. A stratified Basin-wide sampling effort is required in order to update historical contaminant sampling results, act as a baseline for future sampling initiatives and to identify additional mercury sources, both natural and industrial. It is also recommended that regular sampling be carried out in areas of the Basin where subsistence fishing activity persists. Walleye is the most consistent indicator of mercury contamination and should be the focus of the recommended sampling program.

11.4 FISH/FISH HABITAT RELATIONSHIPS AND INSTREAM DEVELOPMENT

Generating stations within the Basin are classified as either run-of-the-river or peaking, however, most incorporate elements of both types of operating regimes. Existing water licences do not specify instream flow requirements related to fish habitat requirements. Minimum flows imposed downstream from generating stations are related to headpond water quality and the dilution of wastes. Operating guidelines for headwater and mainstem reservoirs include controls and schedules for drawdowns which are often related to spawning habitat requirements of resident fish populations. Generally managers voice concerns regarding habitat when low flows are experienced at critical times of the year. Hydroelectric utility managers attempt to address fish habitat concerns on a voluntary basis. Where the maintenance of minimum flows during critical periods (e.g. spawning and incubation) is an ongoing concern, it is recommended that appropriate fish habitat-discharge curves be developed as a basis for negotiations. Stalnaker and Arnette (1976) provide a good summary of these methodologies.

The majority of instream development in the Basin took place in the first half of this century. Fish habitat utilization and migration were not major concerns to managers at that time. No existing facilities provide for upstream fish passage. In the case of lake sturgeon, failure to provide habitat or access to required habitat between impoundments has resulted in the isolation and contributed to the decline of segments of river populations (Nowak and Hortiguera 1986, Payne 1987). It is not known whether populations of other fish species have suffered similar fates. Access to spawning areas and passage between juvenile and adult habitat areas should be maintained for all fish species exhibiting migratory behavior. It will be necessary to establish habitat utilization relationships for species at risk in order to ensure that macrohabitat requirements are met where range fragmentation is a concern. The documentation of spawning and nursery habitat should become a baseline data requirement for all new instream development.

River systems in the Basin have tremendous potential for additional hydroelectric development (Smith 1978) and utility managers are considering redevelopment/facility upgrades at several existing sites in order to make more efficient use of available water resources. As instream development in river systems proceeds and water lease agreements are renegotiated, managers will be presented with opportunities to integrate environmental concerns with hydraulic operating plans. New hydroelectric utilization guidelines (HUG) should mitigate ecological impacts by maintaining habitat diversity and the integrity of critical habitats.

Prior to the construction of new hydroelectric facilities, proponents are required to conduct a fish species inventory and identify potential fish habitat in the vicinity of new development (OMNR 1990b). Typically, this involves a point-in-time investigation of fish presence/absence and relating local bathymetry and substrate information to fish habitat utilization literature. From this process, developers and managers negotiate appropriate mitigation and/or habitat compensation. This 'snapshot' approach fails to document local habitat use. Consequently developers may be required to protect 'suspected' habitat while missing real habitat values.

Historically, fisheries investigators have paid little attention to defining macrohabitat use by fish and have not measured habitat variables. Few studies have focused specifically upon habitat relationships. This lack of information means that developers and managers must rely upon habitat relationships established elsewhere in North America in order to predict the consequences of proposed and existing instream development. These relationships must be defined for Clay Belt, Abitibi River watershed and Lowland fish communities if managers are to provide meaningful input to future instream flow discussions.

It is impractical to examine habitat utilization for every species within a given fish community. Flow alterations tend to adversely affect fish community structure by reducing the abundance of species utilizing shallows (e.g. bars and riffles) and slack water habitats. Approaches for setting flow requirements for fisheries management purposes should be based on the biology of such species. In 1992, resource managers, scientists and stakeholders met to discuss future development in the Basin (Greig *et al.* 1992). Workshop participants recommended that a fish habitat guild classification be developed in order to select appropriate indicator species upon which to base habitat utilization models. Fish guilds and assemblages have been used extensively as descriptors of habitat utilization in flowing waters (Aadland 1993, Lobb and Orth 1991, Leonard and Orth 1988). Guild organization should take into consideration life history stages and seasonal habitat preferences of various species. Table 23 represents a first attempt to organize species considered in this manuscript into macrohabitat use guilds based upon information discussed in previous sections. Further documentation of habitat utilization is required in order to fill information gaps associated with specific life history stages (e.g. YOY and juvenile habitat preferences, and seasonal habitat use), acquire knowledge on the biology of additional river dwelling species (e.g. cyprinids) and validate the relationships presented below. Table 23 implies the existence of 64 different guilds, once seasonal habitat use is considered. The importance of individual guilds will vary with local habitat concerns. Species termed 'habitat generalists' will belong to many guilds. Most species likely require specialized habitat features in order to complete critical stages of their life histories (e.g. reproduction).

Once managers define species assemblages utilizing channel or macrohabitat features, determine which guilds are most likely to be affected by habitat alterations and have chosen appropriate indicator species, it will be necessary to develop microhabitat suitability relationships (HSI). Suitability models are species specific. They establish usable and optimal ranges for key environmental variables (e.g. flow, depth). The United States Fish and Wildlife Service has developed standard procedures to develop HSIs (Bovee 1986), however, a standard, habitat based approach to fish sampling must be developed for use in the turbid waters of the Basin.

Instream habitat modelling has become increasingly common as a means to protect fish habitat. Numerous models designed to mathematically relate physical and biological aspects of rivers systems exist. Most are complex and require extensive data collection. Perhaps the most popular of these is the Incremental Instream Flow Methodology (IFIM) and the Physical Habitat Simulation Model (PHABSIM), which quantify the response of fish habitat to changes in flow. These particular models were developed for use primarily for salmonid species. Instream

Table 23: Macrohabitat guilds for selected fish species, Moose River Basin.

Macrohabitat Utilization	Life History Stage		
	Spawners	YOY/Juveniles	Adult
1. Pools and Headponds	goldeye (sp)	l. sturgeon (sp)	goldeye (w) walleye (sp) l.n. suckers (sp) sturgeon (w) l. whitefish (su)
2. Rapids	l. sturgeon (sp) mooneye (sp) sauger (sp) walleye (sp) l.n. suckers (sp) c.w. suckers (sp) l. whitefish (au)		sauger (su) walleye (su)
3. Channel Flats/Runs		walleye (su)	l. sturgeon (su) sauger (su) n. pike (su) goldeye (su) l.n. suckers (su/au) c.w. suckers (sp/su/au)
4. Perimeter/Edge Habitat (slack water, back eddies, tributary mouths)	n. pike (sp)	n. pike goldeye sauger walleye l.n. suckers c.w. suckers	walleye n. pike (sp) c.w. suckers (sp/su) l.n. suckers (su)

(sp): spring (su): summer (au): autumn (w): winter

flow modelling may represent the best way to manage fish habitat in the future however considerable effort is required to determine which model(s) is most appropriate for use in the Basin. Before any such models can be utilized in northeastern Ontario, they must be validated and calibrated for local use.

The United States Fish and Wildlife Service has developed Habitat Evaluation Procedures (HEP) to document the quality and quantity of available habitat for selected indicator species (USFWS 1980). The HEP incorporates habitat suitability (HSI) modelling with habitat assessment techniques. By defining discrete habitat units, HEP enables managers to conduct impact assessments, habitat trade-off analyses and provides the basis for habitat compensation agreements. The HEP may provide a cost effective fish habitat management alternative to instream flow modelling. The applicability of HEP to rivers within the Clay Belt and the lowlands should be investigated.

12.0 INFORMATION GAPS AND MANAGEMENT RECOMMENDATIONS SUMMARY

The following summary is provided to identify information priorities and provide direction for managing river dwelling fish populations. The reader should refer to previous sections for additional details.

- 12.1 Maintain local databases identifying spawning locations and documenting spawning activity.** Data collection should include dates, water temperatures, gross descriptions of habitat use, behavioral observations and, where possible, measurements of habitat features, e.g. substrate, depth, water velocities, water levels, discharge rates.
- 12.2 Extend closed seasons where post-spawning, early season fish yields are a concern.**
- 12.3 Develop regional macro/microhabitat utilization databases for Clay Belt, Abitibi River watershed, and lowland river fish communities.** This database should reflect seasonal habitat use and various life history stages of fish species in river channels and reservoirs. Future fish assessment and monitoring initiatives should be designed to include a habitat based sampling protocol in order to provide input to these databases.
- 12.4 Examine existing traditional knowledge to document fish habitat utilization in lowland river fish communities.**
- 12.5 Identify physiological indices of change in river dwelling fish species in relation to various forms of development.** Fisheries data sets generated from ongoing monitoring and research initiatives should be scrutinized for clues related to environmental change. This should be a priority for future research initiatives
- 12.6 Conduct a Basin-wide contaminant sampling study.** The objectives of this study should include the development of a baseline for future reference and identification of heavily contaminated watersheds or geographic zones. Sampling should be conducted in developed and undeveloped areas, in reference to various forms of development, e.g. mining, municipal.

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- 12.7 Undertake regular fish contaminant sampling within areas supporting subsistence fisheries.**
- 12.8 Develop fish habitat-discharge relationships for specific sites where the maintenance of fish habitat and instream flows are an ongoing concern.** e.g. below storage reservoirs and hydroelectric facilities.
- 12.9 Continue to define movements of migratory fish species.**
This information will be critical in addressing habitat fragmentation concerns related to future development initiatives.
- 12.10 Develop regional macrohabitat utilization guilds to describe fish species assemblages in relation to gross channel morphological features.**
- 12.11 Identify appropriate indicator species representative of fish habitat utilization guilds.** Habitat suitability models should be developed in order to define usable and optimal ranges of critical habitat variables for indicator species.
- 12.12 Investigate the applicability and feasibility of utilizing IFIM, PHABSIM and other instream flow models, in northeastern Ontario rivers.**
- 12.13 Investigate the applicability and feasibility of utilizing HEP as a fish habitat management tool in northeastern Ontario rivers.**

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Appendix I. A summary of catch rates (CPUE) recorded for juvenile and adult sturgeon from selected river index netting projects (gillnets only), Moose River Basin.

Location (Source)	Timing	Gear (mm)	CPUE (no/hr)	Percent Catch by nos.	Habitat Type Sampled
I. Juveniles					
Groundhog River/Carmichael Falls Headpond					
(Phoenix and Rich 1988)	May	25-127	0.399	58.3	Riverine
(NEA 1989)	June	..	0.766	71.4	Riverine
		229	0.090	—	..
		252	0.078	—	..
(NEA 1992)	May	25-115	0.745	66.8	Headpond
		229	0.480	—	..
		252	0.071	—	..
	May	25-115	1.374	79.9	Riverine
		229	0.037	—	..
		252	0.025	—	..
	June	25-115	0.409	69.3	Headpond
		229	0.097	—	..
	June	25-115	0.617	70.1	Riverine
		229	0.046	—	..
	Aug.	25-115	0.601	55.4	Headpond
		229	0.085	—	..
	Aug.	25-115	0.491	72.1	Riverine
		229	0.109	—	..
	Sept.	25-115	0.082	36.5	Headpond
		229	0.018	—	..
	Sept.	25-115	0.289	47.1	Riverine
		229	0.068	—	..
(NEA 1993)	June	25-115	0.406	35.8	Headpond
		168	0.291	—	..
		203	0.035	—	..
		229	0.000	—	..
	June	25-115	2.161	73.5	Riverine
		168	0.764	—	..
		203	0.113	—	..
		229	0.000	—	..
(BAR 1995)	June	25-115	0.173	21.4	Headpond
		168	0.079	—	..
		203	0.005	—	..
		229	0.009	—	..

Appendix I. continued

Location (Source)	Timing	Gear (mm)	CPUE (no/hr)	Percent Catch by nos.	Habitat Type Sampled
(NEA 1995)	June	25-115	0.678	52.4	Riverine
		168	0.313	—	..
		203	0.015	—	..
		229	0.030	—	..
(Seyler 1997)	June	25-115	0.913	71.9	Riverine
		152	0.115	—	..
		203	0.023	—	..
	July/Aug.	25-115	0.978	63.4	Riverine
		152	0.100	—	..
		203	0.013	—	..
	Sept.	25-115	0.575	39.9	Riverine
		115	0.105	—	..
		203	0.050	—	..
	Sept.	25-115	0.892	53.7	Riverine
II. Adults					
Abitibi River					
Headpond (OMNR 1984)	May/June	76-129	0.005	1.6	
		152	0.042	—	..
		229	0.023	—	..
		305	0.030	—	..
(CIMA 1991)	July 25-129	0.00	0.0		Riverine
		152	0.00	—	..
		168	0.00	—	..
		203	0.008	—	..
		229	0.029	—	..
		252	0.014	—	..
(EAG 1980)	Sept.	25-129	0.090	34.5	Riverine (lowlands)
Kapuskasing River					
(OMNR 1993)	July/Aug.	203	0.079	—	Riverine
		252	0.036	—	..
		305	0.036	—	..

Appendix I. continued

Location (Source)	Timing	Gear (mm)	CPUE (no/hr)	Percent Catch by nos.	Habitat Type Sampled
Mattagami River/Lower Groundhog River					
(Sheehan and McKinley 1992)	May	76-129	0.189	27.1	Riverine
		203	0.425	—	..
		203	0.082	—	Headpond
	June	203	0.107	—	Riverine
		203	0.127	—	
Headpond					
	July	203	0.092	—	..
	Aug.	203	0.164	—	Riverine
	Sept./Oct.	76-129	0.027	6.8	Riverine
		203	0.238	—	..
		76-129	0.023	8.8	Headpond
		203	0.118	—	..
(Lucking 1971)	Oct.	25-129	0.020	2.9	Headpond
(Rossiter 1992)	June	25-129	0.051	6.2	Riverine
	July	..	0.231	22.0	..
(Rossiter 1993)	May/June	25-129	0.151	13.1	Riverine
	July/Aug.	..	0.191	18.0	..
(Sheehan 1989)	June/July	25-129	0.045	5.3	Riverine
		..	0.00	—	Kipling Hp.
		..	0.00	—	Harmon Hp.
		..	0.006	—	Smoky Hp.
		..	0.037	2.89	L.L. Hp.
(Lawson 1983)	May/June	76-129	0.810	—	Riverine
(Nowak 1984)	July/Aug.	76-85	0.180	—	Riverine
	July/Aug.	76-129	0.190	—	Riverine
Upper Mattagami River					
(Nowak 1984)	June-Aug.	85-140	0.00	—	Headpond
		168	0.007	—	..
		229	0.001	—	..
		252	0.014	—	..
		85-140	0.00	—	Headpond
		168	0.004	—	..
		229	0.004	—	..
		252	0.006	—	..

Appendix II. A summary of catch rates (CPUE) recorded for walleye from selected river index netting projects, Moose River Basin.

Location (Reference)	Timing	Gear (mm)	CPUE (no/hr)	Percent Catch by nos.	Habitat Type Sampled
I. Gillnetting					
Abitibi River					
(CIMA 1991)	July	25-254 (152 m)	0.023	3.78	Riverine habitat
			0.236	14.33	Headpond influence
(EAG 1980)	Oct.	25-127 (30.4 m)	0.046	17.4	Lowlands, riverine
(Gibson <i>et al.</i> 1985)	May/June	77-127	0.292	14.4	Headpond
Groundhog River					
(Phoenix and Rich 1988)	May	38-127 (152 m)	0.081	6.2	Riverine habitat
(NEA 1989)	May-June	38-127 (152 m)	0.104	8.9	Riverine habitat
(NEA 1992)	May	..	0.158	14.2	Riverine habitat
	July	..	0.054	9.3	
	Aug.	..	0.167	16.3	
	Oct.	..	0.016	7.6	
	May	..	0.080	4.9	Riverine habitat
	July	..	0.147	13.5	
	Aug.	..	0.074	10.0	
	Oct.	..	0.126	15.7	
(NEA 1993)	June	38-115	0.128	11.1	Riverine habitat
			0.493	16.8	

Appendix II. continued

Location (Reference)	Timing	Gear (mm)	CPUE (no/hr)	Percent Catch by nos.	Habitat Type Sampled
(BAR 1995)	June	..	0.082 0.323	10.2 25.0	Riverine habitat
(Seyler 1994)	June July Sept. Sept.	38-127	0.102 0.071 0.083 0.063	6.6 3.9 4.9 4.0	Riverine habitat
Mattagami River and Generating Station Complex					
(Rossitter 1993)	June July	25-127 ..	0.406 0.433	49.7 41.4	L. Groundhog, Mattagami River
(Rossitter 1992)	May/June July/Aug.		0.456 0.329	39.6 31.0	L. Groundhog, Mattagami River
(Sheehan 1989)	May-July	25-127 (137 m)	0.043 0.167 0.065 0.106	8.7 11.4 17.2 5.9	Lowland, riverine L.L. headpond Harmon headpond Smoky headpond
(Sheehan and McKinley 1992)	Aug. Sept./Oct. Sept./Oct.	75-127	0.279 0.154 0.063	31.4 39.2 24.1	L. Groundhog, Mattagami River L.L. headpond
(Lucking 1971)	Sept.-Oct.	38-127 (106 m)	0.117	19.3	L. Mattagami River
II. Trapnetting					
	(no/24hr.)				
(BAR 1986)	May	6'	4.11	2.1	Chapleau River
(CIMA 1991)	July	6'	0.90	11.4	Abitibi River
(Gibson <i>et al.</i> 1985)	June - July	6'	0.00	0.0	Abitibi River (headpond)
(OMNR 1993)	Aug.	6'	0.84	36.2	L. Kapuskasing River

Appendix III. Contaminant sampling data for walleye, Moose River Basin.

Site	Year	Mean [Hg] (ppm)	Reg. Corr. (r)	Sample Size (n)
I. Abitibi River Watershed				
Lake Abitibi	1971	0.98	149	
	1973	0.87		11
	1980	0.98	0.592	30
	1984	0.77	0.606	20
	1985	1.06	0.329	23
	1990	1.01(2)		19
Abitibi River (Iroquois Falls) (L. Sault River) (Island Falls) (Abitibi Canyon) (Onakawana)	1977	1.60(3)		15
	1977	0.99	0.619	12
	1989	1.21	0.499	12
	1977	1.14(1)		15
	1977	1.22(2)	0.863	5
	1980	0.75		15
	1981	0.74	0.842	15
Frederickhouse Lake	1977	0.87		16
	1980	0.54	0.529	15
	1990	0.28	0.623	17
Pierre Lake (reference)	1977	0.90	0.861	15
II. Groundhog River Watershed				
Ivanhoe Lake	1977	0.47	0.739	15
Horwood Lake	1977	0.64	0.850	15
Groundhog Lake	1978	0.87	0.877	15
Carmichael Generating Station	1990	0.62	0.551	25
	1992 upstr.	1.13(2)	0.399	15
	1992 down	1.62(3)	0.267	17
L. Groundhog River	1984	1.14(1)	0.824	17
III. Kapuskasing River Watershed				
Chapleau River	1978	0.39	0.924	15
Kapuskasing Lake	1979	0.64	0.689	15
U. Kapuskasing River	1981	1.32		16
	1992	2.15	0.313	10
L. Kapuskasing River	1979	0.64	0.689	15
	1981	0.62		16
	1992	1.49	0.482	11

Appendix III. continued

Site	Year	Mean [Hg] (ppm)	Reg. Corr. (r)	Sample Size (n)
IV. Mattagami River Watershed				
Minisinakwa Lake	1976	0.83		51
	1981	1.03(2,4)	0.937	15
Mattagami Lake	1976	0.93(4)		38
	1981	1.30(4)	0.846	15
Kenogamissi Lake	1977	0.56		11
Mattagami River (Timmins) (Sturgeon Falls)	1982	0.93	0.747	9
	1975	0.42		113
	1982	0.31		9
(Smooth Rock Falls. upstream)	1977	0.38	0.799	13
	1990	0.56	0.824	19
(Smooth Rock Falls downstream)	1977	0.94	0.769	12
	1990	0.53	0.553	19
(Groundhog River confluence)	1983		1.04	19
	1990	0.89(2)	0.635	20
	1991	0.82	0.871	20
Little Long Generating Station headpond	1986	1.32(2)	0.919	22
Harmon Generating Station headpond	1986	1.66(2)	0.946	11
V. Missinaibi River Watershed				
Missinaibi Lake	1977	0.39	0.547	15
	1991	0.85	0.780	20
Opasatika Lake	1983	0.54	0.876	28
	1988	0.54	0.676	20
VI. Moose River				
	1978	1.28(2,4)	0.616	16
	1979	0.87		25
	1980	1.11		19
	1981	0.77		15

(1) Fish > 30 cm exceed 1.0 ppm [Hg] standard

(2) Fish > 35 cm exceed 1.0 ppm [Hg] standard

(3) Fish > 30 cm exceed 1.5 ppm [Hg] and should not be consumed

(4) Fish > 45 cm exceed 1.5 ppm [Hg] and should not be consumed

index netting

projects, Moose River Basin.

Location (Source)	Timing	Gear (mm) (net length)	CPUE (no/hr)	Percent Catch by nos.	Habitat Type Sampled
I. Gillnetting					
Abitibi River					
(CIMA 1991)	July	25-254 (152 m)	0.090	6.9	Headpond influence
(NES 1993)	Oct.	25-254 (137 m)	0.040	8.5	Headpond influence
(Gibson <i>et al.</i> 1985)	May-June	77-254 (91.4 m)	0.062	8.6	River and headpond
(EAG 1980)	Oct.	25-127 (30.4 m)	0.027	10.3	Lowlands, riverine
Groundhog River					
(Phoenix and Rich 1988)	May	38-127 (152 m)	0.061	4.9	Riverine habitat
(NEA 1989)	May-June	38-127 (152 m)	0.048	4.1	Riverine habitat
(NEA 1992)	May	..	0.012	0.7	Riverine habitat
	July	..	0.100	9.6	
	Aug.	..	0.010	1.4	
	Oct.	..	0.046	5.7	
	May	..	0.062	5.5	Riverine habitat
	July	..	0.026	4.7	
	Aug.	..	0.071	6.9	
	Oct.	..	0.028	13.4	
(NEA 1993)	June	38-115 (152 m)	0.085	2.9	Riverine habitat
			0.043	3.7	
(BAR 1995)	June	..	0.037	4.5	Riverine habitat
			0.118	9.1	
(Seyler 1994)	June	38-127	0.029	1.9	Riverine habitat
	July/Aug.	..	0.025	1.8	
	Sept.	..	0.083	5.1	
	Sept.	..	0.075	6.9	

Appendix IV. continued

Location (Source)	Timing	Gear (mm) (net length)	CPUE (no/hr)	Percent Catch by nos.	Habitat Type Sampled
Mattagami R. and Generating Station Complex					
(Rossitter 1993)	June	38-127	0.043	5.3	L. Groundhog,
	July	..	0.012	1.1	Mattagami River
(Rossitter 1992)	May/June	..	0.063	5.4	..
	July/Aug.	..	0.068	6.5	..
(Sheehan 1989)	May-June	25-127 (137 m)	0.153	10.4	L.L. headpond
	..	..	0.069	18.3	Harmon headpond
	..	..	0.013	1.4	Smoky Falls headpond
	..	..	0.003	2.0	Kipling headpond
	..	..	0.004	0.8	Lowlands, riverine
(Sheehan and McKinley 1992)	Aug.	75-127	0.004	0.5	L. Groundhog and Mattagami River
	Sept./Oct.	..	0.022	5.7	..
	Sept./Oct.	..	0.029	11.1	L.L. Headpond
(Lucking 1971)	Sept.- Oct.	38-127 (106 m)	0.073	11.1	L. Mattagami River and L.L. Headpond
II. Trapnets			(no./24 hr.)		
(CIMA 1991)	July	6'	2.4	22.2	River and headpond influence, Abitibi River
(Gibsonet <i>et al.</i> 1985)	May-July	6'	1.1	1.6	River and headpond Abitibi River
(OMNR 1993)	Aug.	6'	0.57	24.6	headpond influence Kapuskasing River
(MacRitchie 1984)	May-June	6'	2.1	22.0	Spawning sites, Mattagami and Kamiskotia Rivers
(Nowak and MacRitchie 1984)	June	6'	1.2	8.0	Frederick House River
(BAR 1986)	May	6'	2.55	2.5	Chapleau River

Note: CPUE for gillnets represents total catch per unit effort of all mesh sizes indicated.

Appendix V. Contaminant sampling results for northern pike in the Moose River Basin.

Site	Year	Mean [Hg] (ppm)	Reg. Cor. (r)	Sample Size (n)
I. Abitibi River Watershed				
Lake Abitibi (storage reservoir)	1971	0.79		67
	1973	0.60		7
	1974	0.59		16
	1980	1.21		15
	1990	0.74		20
Abitibi River (Iroquois Falls)	1977	1.15(1)	0.848	4
Abitibi River (Island Falls)	1977	1.14(2)	0.901	15
Pierre Lake (reference)	1977	1.20(2)	0.879	15
Nighthawk Lake	1977	0.71(3)	0.919	15
Frederick House Lake	1980	0.27	0.754	10
	1990	0.11	0.726	18
Little Abitibi River	1981	0.38	0.542	15
II. Groundhog River Watershed				
Ivanhoe Lake	1977	0.43(3)	0.838	15
Horwood Lake	1977	0.43(1)	0.831	15
Groundhog Lake	1978	0.87(1)	0.830	15
Groundhog River (Carmichael Falls)	1979	0.42		4
	1989	0.82		9
	1990	0.65		7
	1992	0.88		9
Lower Groundhog River	1983	0.96(2)	0.824	14
III. Kapuskasing River Watershed				
Chapleau River	1978	0.34	0.716	15
Kapuskasing Lake	1979	0.71(1)	0.522	15
Kapuskasing River (downstream of town of Kapuskasing)	1970	1.35(2)		16
	1990	0.62	0.976	5
IV. Mattagami River Watershed				
Minisinakwa Lake	1976	0.74(1)		12
	1981	0.46(3)	0.863	12
Mattagami Lake	1976	1.24(2)		12
	1981	0.67(3)	0.886	11
Kenogamissi Lake	1977	0.54(3)	0.607	22

Appendix V. Continued

Site	Year	Mean [Hg] (ppm)	Reg. Cor. (r)	Sample Size (n)
Mattagami River (Sturgeon Falls)	1970	0.26		12
	1975	0.42		21
(upstream Mallette Pulp and Paper)	1977	0.48		4
	1990	0.59		4
(Cypress Falls)	1970	0.43		13
	1983	0.61	0.626	20
	1990	0.86(2)	0.815	10
	1991	0.50(3)	0.609	22
Little Long Generating Station headpond	1986	0.69(2)	0.928	27
Harmon headpond	1986	1.67		4
V. Missinaibi River Watershed				
Opasatika Lake	1983	0.43	0.553	13
	1988	0.55	0.460	20
VI. Moose River				
	1978	0.68	0.875	16
	1979	0.43		22
	1980	0.66	0.789	13
	1981	0.34		15
	1984	0.28		5

(1) Fish > 30 cm exceed 0.5 ppm [Hg] unlimited consumption standard

(2) Fish > 65 cm exceed 1.5 ppm [Hg] and should not be consumed!

(3) Fish > 45 cm exceed 0.5 ppm [Hg] standard

Appendix VI. A summary of catch rates (CPUE) recorded for catostomids from selected river index netting projects (gillnets only), Moose River Basin.

Location (Source)	Timing	CPUE (no.hr)				Percent Catch				Habitat Type Sampled
		CWS	LNS	RHS	Total	CWS	LNS	RHS	Total	
Abitibi River										
(CIMA 1991)	July	.306	.277	.011	.594	43.1	39.4	1.5	84.0	River Headpond
		.168	.369	.032	.569	11.7	25.0	2.2	38.9	
(Gibson <i>et al.</i> 1985)	May/ June	.213	.112	.317	.642	9.7	5.4	15.4	30.5	Headpond
Groundhog River										
(NEA 1989)	May/ June	.120	.024	—	.144	10.2	2.1	—	12.3	River
(NEA 1992)	May	.070	.026	—	.096	7.9	2.7	—	10.6	Headpond
	July	.058	.021	—	.079	8.1	3.0	—	10.1	
	Aug.	.172	.007	—	.179	16.2	0.7	—	16.9	
	Oct.	.058	.000	—	.058	34.8	0.0	—	34.8	
	May	.191	.073	—	.264	10.1	4.1	—	14.2	River
	July	.082	.016	—	.098	21.7	4.3	—	14.2	
	Aug.	.162	.030	—	.192	22.2	4.1	—	26.3	
	Oct.	.078	.024	—	.102	34.5	10.3	—	44.8	
	May	.161	.048	—	.209	9.3	2.8	—	12.1	River
	July	.042	.010	—	.052	3.8	0.9	—	4.7	
	Aug.	.043	.012	—	.055	5.7	1.4	—	7.1	
	Oct.	.161	.058	—	.219	20.2	7.1	—	27.1	
(NEA 1993)	June	.310	.200	—	.510	42.4	27.4	—	69.8	Headpond
		.297	.304	—	.600	23.6	24.1	—	47.7	River
(Seyler 1994)	June	.076	.085	—	.161	2.6	2.9	—	5.5	River
		.049	.011	—	.060	20.3	4.7	—	25.0	River
		.382	.054	—	.436	14.0	3.1	—	17.1	
		.614	.051	—	.665	36.1	2.8	—	38.9	
	Sept.	.303	.043	—	.346	30.3	4.3	—	34.6	

Appendix VI. continued

Location (Source)	Timing	CPUE (no.hr)				Percent Catch				Habitat Type Sampled
		CWS	LNS	RHS	Total	CWS	LNS	RHS	Total	
Mattagami River and Generating Station Complex										
(Rossiter 1993)	June	.170	.086	—	.256	20.9	10.6	—	31.5	L. Groundhog Mattagami River
	July	.214	.123	—	.337	20.5	11.8	—	32.3	
(Rossiter 1992)	June	.220	.197	—	.417	19.1	17.1	—	36.2	L. Groundhog Mattagami River
	July	.231	.155	—	.386	21.8	14.6	—	36.4	
(Sheehan 1989)	May/	.098	.470	—	.568	14.4	37.1	—	51.5	Little Long headpond
	July	.105	.575	—	.680	73.3	7.7	—	81.0	Smoky
		.065	.147	—	.212	30.9	39.4	—	70.3	Harmon
		.027	.068	—	.095	18.8	43.0	—	69.7	Kipling
		.019	.185	.059	.263	3.9	43.0	10.5	57.4	Lowland
(Sheehan and McKinley 1992)	Aug.	.288	.056	—	.344	32.4	6.3	—	38.7	L. Groundhog Mattagami River
	Sept./	.136	.045	—	.181	34.6	11.4	—	46.0	
	Oct.	.076	.056	—	.132	29.1	21.3	—	50.4	Little Long headpond
(Lucking 1971)	Sept.	.134	.258	—	.392	19.9	38.3	—	58.2	River & Headpond

